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TECHNOLOGY IN OUR ECONOMY

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MONOGRAPH No. 22

TECHNOLOGY IN OUR ECONOMY

LEWIS L. LORWIN AND JOHN M. BLAIR

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The Temporary National Economic Committee is greatly indebted to these authors for this contribution to the literature of the subject under review.

The status of the materials in this volume is precisely the same as that of other carefully prepared testimony when given by individual witnesses; it is information submitted for Committee deliberation. No matter what the official capacity of the witness or author may be, the publication of his testimony, report, or monograph by the Committee in no way signifies nor implies assent to, or approval of, any of the facts, opinions, or recommendations, nor acceptance thereof in whole or in part by the members of the Temporary National Economic Committee, individually or collectively. Sole and undivided responsibility for every statement in such testimony, reports, or monographs rests entirely upon the respective authors.

(Signed) JOSEPH C. O'MAHONEY.
Chairman, Temporary National Economic Committee.

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LETTER OF TRANSMITTAL

Hon. Joseph C. O'Mahoney,
Chairman, Temporary National Economic Committee,
Washington, D. C.

My Dear Senator: The monograph Technology in our Economy is a tribute to the frontier thinking and sustained effort of Dr. Dewey Anderson. He organized the study, selected the authors, and maintained close supervision of its progress from the first-submitted outlines until its completion. In no small measure, this study has been the outgrowth of his continued study of occupational and employment trends during the past 10 years. It took concrete form as a result of the Temporary National Economic Committee's hearings on Technology and the Concentration of Economic Power, for which Dr. Anderson was the Committee's counsel.

The Temporary National Economic Committee hearings on technology brought together representatives of management and organized labor in industries which use great amounts of capital, are much subject to technological change, and employ large aggregates of labor. By so doing, a sample representative of conditions prevailing in the national economy was secured. The hearings were opened with an overview of the impact of technology on modern society. It was my privilege, as first witness before the Committee, to contrast the growth of technology during the era of independent invention and mechanical power up to the Civil War with the discovery of the "art of invention" by modern industry, by means of which great corporations conduct research, control patents, and through their use of mass production machinery and electric power obtain places of dominance in their respective fields. Thus, technology itself becomes a tool facilitating the concentration of economic power. Furthermore, the access to advanced technology is lodged in relatively few corporate groups, as attested by the fact that in 1938 thirteen corporations, representing 0.8 percent of all companies conducting industrial research, employed a third of all industrial research workers.

But while technology raises questions of monopoly advantages with which public policy must necessarily come to terms, it likewise offers hope of achieving that state of abundance in production and variety of goods which will free economic man from the tyranny of want and privation. There is much evidence in the testimony of social scientists, industrialists, and labor leaders who appeared before the Committee that the American frontiers have not been reached, that living standards of our people are miserably low in comparison with our technological capacity to produce and distribute goods and services. Here lies the hope and challenge of modern technological society.

The T. N. E. C. hearings on technology appear in part 30 of the series of hearings. They constitute the most up-to-date and comprehensive body of facts ever assembled on this important subject. Management was represented by such witnesses as Edsel Ford, president of the Ford Motor Co.; Charles F. Kettering, vice president of General Motors Corporation; Thomas Watson, president of International Business Machines Corporation; Fowler McCormick, vice president of the International Harvester Co.; William Henry Harrison, vice president of the American Telephone & Telegraph Co., and Charles Hook, president of American Rolling Mills. Witnesses for labor included William Green, president of the American Federation of Labor; Philip Murray, now president of the C. I. O.; George Harrison, president of the Brotherhood of Railway Clerks, representing the railway brotherhoods; A. F. Whitney, president of the Brotherhood of Railroad Trainmen; R. J. Thomas, president of the United Automobile Workers; Emil Rieve, president of the Textile Workers Union; and Thomas Kennedy, secretary of the United Mine Workers. Their testimony and the material which they submitted should be read in conjunction with this monograph in order to obtain a well-rounded view of technology's place in our present-day economy.

Dr. Lewis Lorwin, the author of Part I: Technology in Economic Thought, is a former Brookings Institution economist, lately with the International Labour Office in Geneva, Switzerland. His eminence in the field of economy theory and labor problems is attested by a long and substantial series of periodical and book publications. He has brought to the present assignment the accumulation of years of experience, and his critical faculty has developed a document of unusual merit. Unfortunately, limitation of time at Dr. Lorwin's disposal has made it necessary to leave untouched certain essential parts of the theoretical discussion. The sequence of topics in the material presented in Part I is broken in two places. Had time permitted, two sections dealing with cyclical unemployment in 1921–23 and the rationalization of unemployment in Europe would have appeared after the item "Early statements". Also the topic of technocracy and its implications would have been inserted following the item "The classical debate". Appendix K has been included to indicate the scope of the outline which it was intended to cover. Dr. Lorwin wishes to acknowledge his appreciation to Mr. Arthur W. Wubnig, who collaborated with him in the preparation of the section dealing with measurement of reemployment opportunities.

John M. Blair has written Part II: Technology and Economic Balance, under the supervision of Dr. Anderson. Although the author has devoted many years of scientific work to the study of technology and its economic effects, the time at his disposal for writing the monograph was limited to four months between the closing of Hearings on technology and the Committee deadline for submitting monographs. Ruth Aull, technical assistant on the Temporary National Economic Committee staff, was handed the draft manuscript of part II, reorganized it in substantial part, and rewrote much of it, contributing materially to making it the smooth-reading and well-knit monograph which is submitted here. Elizabeth W. Breid rendered valuable assistance in checking data.

Part II is an attempt to answer certain moot questions concerning the impact of technology in modern life which affect the balance between the forces necessary to continue an expanding capitalistic economy. That it does not conclusively prove the thesis of imbalance is due primarily to the paucity of data available for an inductive treatment of the issue. But substantial material has been assembled here, some of it original with this study, some adapted from other sources, which should aid in the solution of many questions concerning the role of technology today.

The Committee is indebted to these several authors and their assistants for the assembly and presentation of this body of information and conclusions.

Respectfully submitted.

THEODORE J. KREPS,
Economic Adviser.

NOVEMBER 23, 1940.

newer approaches in economic research cast considerable doubt on the comforting generality of classical economics that there can be no long-term imbalance in a competitive capitalistic economy. The technology hearings of the T. N. E. C. developed testimony concerning industrial production and the labor supply in the decades 1870–80, 1890–1900, and 1929–39. In every important respect the depression of the 1930's has been far more severe and persistent than any depression suffered in the earlier decades. It occurred in a country whose technology had reached an advanced stage. This does not necessarily indicate a fundamental change in the economy as compared with the conditions prevailing in the earlier decades. But there is unmistakable evidence of a change in kind as well as severity of unemployment in the last depression. This change is characterized by the widespread use of electrical power and mass production methods which have shown a capacity to increase industrial activity on the upturn of the business cycle without a corresponding ability to absorb unemployed labor.

The problems of technology developed in the Committee's hearings on that subject have been treated at length in part 30. They have been subjected to careful, critical scrutiny in this monograph, where John Blair has examined increasing productivity and the balancing forces of new industries, lowered prices, and reduced working time for the labor force. The conclusions are not final, for many of the data are fragmentary and in some instances only illustrative of what must prove to be profitable areas of future economic research. Yet, they all point in the same direction, namely, that the forces which can be expected to swing the economic pendulum into balance, allowing full employment of the manpower and technological resources of the economy, are not sufficiently powerful to do so, barring some additional support in changed public policy or substantially different business practice.

This monograph is offered not only for its exploratory value, but because it contains factual data invaluable in calculating the forces of a technological character at work in the economy. Such an assembly of facts should aid the Committee in its deliberations of numerous problems and should furnish thoughtful students of economics with material leading to further and more decisive conclusions.

Dewey Anderson,
Executive Secretary, Temporary National Economic Committee

PART I

THE PROBLEM OF TECHNOLOGICAL UNEMPLOYMENT AN HISTORICAL SURVEY

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THE PROBLEM OF TECHNOLOGICAL UNEMPLOYMENT

INTRODUCTION

It is now more than a decade and a half since the phrase "technological unemployment" was coined in the United States. In its first coinage the phrase was meant to convey the idea that technical progress was a factor in decreasing employment and that society was being confronted more and more with the problem of "machines versus men." In the 15 years since the phrase became common currency in this popular sense, an almost incessant debate—sometimes more and sometimes less heated—has been going on as to what the phrase really meant; whether what it meant to denote was a fact or a "mere figment of the imagination"; if a real fact, how serious was it for national welfare and what could or should be done about it. What has been said on both sides of the question is registered in an extensive literature—in the technical discussions of the American statistical and economic associations, in numerous articles in the more or less popular magazines, in editorials in the trade press, in voluminous reports and studies of private research agencies and governmental bureaus, and in the elaborate depositions and statements made in public hearings held by congressional committees and by other official or semiofficial bodies.

It cannot be said that this rather prolonged debate has settled the main issue raised. Today, as a decade ago, opinion in the United States is still divided between the opposing views that may be held on the subject. On the one hand, it is still claimed by some that the factor which is of special significance in making the problem of unemployment what it is today is that of technology. Not only the number of the unemployed, but their distribution by occupations, the duration of their unemployment, and their chances for being reemployed are presumably influenced in large measure, if not primarily, by the technological changes which have been taking place during the past two decades and which promise to continue in the discernible future. On the other hand, there are those in this country as well as abroad who either deny the existence of technological unemployment entirely or regard it as of minor importance. To many of these the very term is a misnomer whose use merely tends to confuse the real issues.

This division of opinion, which is as old as the problem itself, would seem to point to underlying differences in general economic views which cannot seemingly be bridged. It is nevertheless also true that the opposing views on technological unemployment have roots in general economic developments and that the area of disagreement has been narrowed down as a result of closer study of the situation at different times, and especially in recent years.

It is owing to this fact that a survey of the main discussions of the problem and of the studies made can serve as a convenient introduction to the problem today. Such a survey is presented here with a view to drawing from past discussions and studies those points which may be of help to current thinking.

Chapters I and II review some of the principal discussions of the subject in economic and general literature before 1933. No attempt has been made to make this review complete. What is given has been selected presumably because it has a lasting interest, and also throws light on currents of thought in relation to social-economic backgrounds. Chapter III is a more detailed review of recent studies and reports. It is hoped that bringing together, within one brief volume, the main results of recent work in this field bearing on concepts, methods, and the relation of technology to general economic processes will help to clear the ground for a better understanding of the problem in its relation to general economic analysis and to social policy.

CHAPTER I

NINETEENTH CENTURY BACKGROUNDS

EARLY STATEMENTS

Already in the second half of the eighteenth century, during the early stages of the industrial revolution, there was speculation as to the effects of the then new machinery upon the condition of the worker. By the beginning of the nineteenth century the two trends which have persisted in the discussion of the subject found expression in the writings on the one side of Jean-Baptiste Say and on the other of Lord Lauderdale. Say's Traité d'Économie Politique [1] presented the first consistent statement of the optimistic viewpoint. On the other hand, Lord Lauderdale in his An Inquiry Into the Nature and Origin of Public Wealth,[2] raised the question whether the unrestricted use of machinery was always of benefit to the laboring population.

Say's position was that machinery benefited society in general and the worker in particular. His position was based on his "Law of Markets" according to which production creates its own demand.[3] The introduction of machinery meant a saving in costs and lower prices which in turn caused an expansion of the demand for goods in the same or new industries and ultimately an increase in employment. He admitted that machines displaced workers, but he thought that such displacement was a temporary and transitory evil rectified by the growth of wealth and by increased employment which followed as a result of lower prices due to greater productiveness.[4]

Lauderdale's "Inquiry" was one of the earliest statements of a sceptical attitude on the question. Lord Lauderdale's position was influenced by his general view that a distinction must be made by what he called "wealth" and "riches"—that is the individual and the social viewpoint in economics. The riches of the individual depend in part upon scarcity and exchange value, while public or social wealth is determined by abundance.

Lord Lauderdale's main argument was that capital is productive and adds to national wealth only insofar as it serves to supplement labor or to perform such labor as could not otherwise be performed. Hence a country could not be benefited by a greater accumulation of capital than could be employed to supplement labor, in the production of

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[1] First published in 1803; 2d ed., Antoine-August Renouard, Paris, 1814.

[2] Appeared first in 1804; 2d ed. enl., Archibald Constable & Co., Edinburgh, 1819.

[3] "According to Say's Law, every product, once created, offers instantaneously to the full extent of its value a market for other products. This is so because that value is equivalent to the sum of the incomes of the several agents—owners of natural resources, capitalists, entrepreneurs, and workers—who cooperated in creating the product. No general overproduction is therefore possible." (Work Projects Administration, National Research Project, Survey of Economic Theory on Technological Change and Employment, May 1940, p. 47).

[4] "In the early editions of his Treatise, Say * * * suggested * * * intervention by public authority to relieve the 'momentary and local' evils," including public works. (Ibid., p. 48.)

those things for which there already exists a demand. He argued against capital formation through "parsimony" which meant a decrease in the demand for consumers' goods, and hence a diminution in the demand for labor. Public wealth, as opposed to individual riches, could be increased not through saving, but through the "additional exertions of industry." Hence the "baneful passion of accumulation" had to be restrained for the good of all. Insofar as capital increased wealth when its formation was not at the expense of consumption, its growth helped to expand markets and to increase employment. But the expansion of capital was limited by the unequal distribution of wealth which affected economic development unfavorably.

THE CLASSICAL DEBATE

The discussions of Say and Lord Lauderdale were resumed on a more extensive scale and more vigorously by the writers whose works marked the first great advance of economics in England in the decade following the Napoleonic wars. Despite the wastes, destructions, and dislocations of these wars, industrial development had proceeded at a remarkable pace. With the end of the wars, this development took on an even larger amplitude, and was accompanied by the accelerated use and spread of machinery not only in the textile industry but also in the iron trades, in coal mining, and in other industries.

By this time men were becoming more clearly aware of the wide economic and social effects of the industrial changes that had been going on in England (and on a smaller scale also in France, the United States and elsewhere) for over 50 years. This period saw the publication of a number of histories of the rise of manufacturing in England, of the changes in the position of the working class, of the rise of the new middle class and of the various problems in economic and political life which the changes had produced. The beneficial effects of machinery were no longer much in doubt but there persisted a division of opinion as to the immediate effects and the temporary dislocations which machinery was having upon the life and welfare of the workers.

There could be no doubt at the time that large sections of the artisan and laboring population were torn from their accustomed industrial grooves and suffered great economic privations. This was especially true of the skilled workers in the textile industry, the hand-loom weavers. The injured workers brought their plight to public notice by staging the so-called Luddite riots in 1817—the most extensive machine smashing campaign in English history. But other groups of workers were beneficially affected by the growth of industry, especially the workers in the trades where skill was not completely displaced by machinery and in which the demand for the product was expanding.

The deep disturbances produced by this first period of machine-expansion gave rise to a considerable literature which attempted to sum up and to appraise the economic and social changes that had taken place. In general, the writers of this period stressed not only the enormous industrial strides which had been made owing to the use of machinery and the great increase in wealth but also the rise to power of the new middle classes who represented the new spirit

of industrial enterprise, and the consequent changes in political organization and social forms.

With regard to the effects of these changes on the condition of the workers, many writers, more or less socialistic in attitude, painted the dark sides of the picture—the long hours and low wages in the new factories, the exploitation of women and children, the insanitary and miserable housing conditions in the growing cities. But there was carried on an animated debate as to the effects of machinery on labor which was concerned specifically with employment and wages. In this debate the two main trends of thought sketched in the preceding section found expression mainly in the writings of Sismondi on one side and of the "classical school" of economics on the other.

Sismondi attacked the idea that machinery was an unmixed good and that workers displaced by machinery were automatically reemployed.[5] On the basis of his general analysis that productive capacity and consumers' income during any given period are not necessarily balanced, he argued that invention and the introduction of machinery could be an unmixed benefit only if preceded by an increase in demand for goods and for labor which would allow the employment elsewhere of the labor displaced by machinery. Capital accumulation resulting in the introduction of new machinery leads to expanded production. But if the new fixed capital has been saved at the expense of the circulating capital, it means a decrease in mass consumption, the threat of overproduction and unemployment. Sismondi also pointed out that there were difficulties in transferring fixed capital and labor skills and in bringing supply and demand into equilibrium, and that as a result crises are inevitable and the workers must frequently suffer lower wages and unemployment until an adjustment is made. Sismondi was in favor of restricting the adoption of machinery, and of reforms for the development of small scale industry; he was also one of the first to advocate the limitation of working hours for children and other social reforms.[6]

While Sismondi was to exercise influence in later years, the far more influential current of economic thought at the time was represented by the followers of Ricardo—the exponents of the "classical school of economics." Their reasoning on the question was a further development of the position taken by Jean-Baptiste Say, though developed on the basis of Ricardian economic reasoning. But on this particular question, the followers were soon shocked to find themselves at variance with their master. Ricardo, who in the first edition of his Principles of Political Economy and Taxation, published in 1817, has said little new on the subject, was influenced by some of the writings of the period which stressed the difficulties created for the workers by the introduction of machinery. As a result, the third edition of his "Principles," which appeared in 1821, contained a new chapter "On Machinery," which was in contradiction with the unqualified optimistic views of his disciples.

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[5] J. C. L. Simonde de Sismondi, Nouveaux principes d'économie politique, 2d ed., Delaunay, Paris, 1827 (first published in 1819).

[6] For more detailed statement, see Work Projects Administration, National Research Project, Survey of Economic Theory on Technological Change and Employment, May 1940, pp. 48–52.

Ricardo, in line with the general spirit of his economic thinking, was concerned with "the influence of machinery on the interests of the different classes of society. * * * Ever since I first turned my attention to questions of political economy," Ricardo tells us, "I have been of opinion that such an application of machinery to any branch of production as should have the effect of saving labour was a general good, accompanied only with that portion of inconvenience which in most cases attends the removal of capital and labour from one employment to another."[7] Ricardo had not changed his opinion, as he further tells us, "as far as regards the landlord and the capitalist"; but he had become convinced that "the substitution of machinery for human labour is often very injurious to the interests of the class of labourers"[8] and that "the opinion entertained by the labouring class that the employment of machinery is frequently detrimental to their interests, is not founded on prejudice and error but is comformable to the correct principles of political economy."[9]

Ricardo's treatment of the subject, which is brief and somewhat confused, centers on a distinction between the "gross produce" and "net produce" of a country. Landlords and capitalists derive their rents and profits from the "net produce" (or net income), while the "laboring class" depends mainly on the "gross produce." Now, the important thing is that the "net produce," owing to the introduction of labor-saving machinery, may increase at the same time that the gross produce diminishes. That may happen, if as a result of the invention of a new machine, the capitalist would so organize production as to increase the amount of fixed capital and reduce the amount of circulating capital. As the capitalist is only interested in "net produce," he may carry on production with the aid of machinery to a point at which his own income is maintained or even increased while total production is diminished with consequent "distress and poverty" for the workers.

This situation may be offset by the fact that the "net revenue" of the capitalist has a greater purchasing power owing to the lower prices of commodities made possible by the labor-saving machines. As a result, the capitalist can satisfy his wants and at the same time save more and increase his capital which enables him to employ more labor. When this takes place a portion of the people thrown out of work by the introduction of machines are reemployed. If the increased production due to machinery is great enough to allow the capitalist to accumulate sufficient working capital ("food and necessaries"), the entire population may again find employment. In such a case the condition of the working population would be considerably improved, owing to the increased demand for labor and to "the low price of all articles of consumption on which their wages will be expended."

Ricardo warned his readers not to draw "the inference that machinery should not be encouraged." In general, he thought, machinery had undesirable effects when "suddenly discovered and extensively used." But he also thought that, as a rule, the discoveries of machines are gradual, and merely redirect the employment of the capital which is saved and accumulated. The demand for labor continues to

[7] David Ricardo, Principles of Political Economy and Taxation, 3d ed., John Murray, London, 1821, pp. 466–467.
[8] Ibid., pp. 468–469.
[9] Ibid., p 474.

increase with an increase of capital, though in a diminishing ratio. A great deal depends on wages. If wages rise, largely as a result of a rise in the cost of food, more fixed capital will be used. "Machinery and labour are in constant competition, and the former can frequently not be employed until labour rises." [10]

Ricardo also warned against discouraging machinery in any one country, on the ground that it would affect adversely foreign trade and cause capital to move to foreign lands, thus diminishing the demand for labor at home.

Ricardo's followers were not convinced by their master's reasoning on this question, and in general took the optimistic view on the question. They elaborated the "compensatory principle" according to which the workers displaced in one trade or industry are soon reabsorbed in the same or new industries. The most systematic statement of the theory at the time was given by J. R. McCulloch in his Principles of Political Economy, first published in 1830. McCulloch dismisses Ricardo's main argument by saying that it is entirely hypothetical: "In the actual business of the world, machines are never introduced to lessen but always to augment gross produce." [11] He further argues that improvements in machinery are similar in their effects to improvements in the skill and dexterity of the worker. When improvements are introduced into an industry, they result in lower costs of production, which tend to reduce the price of the commodity produced. As prices are reduced, the demand for such commodities increases, and an "additional number of hands" is employed to supply the increased demand. If the demand for a specific commodity is inelastic, the reduction in its price releases income, which is used either to purchase larger quantities of other things or to increase the savings of "persons belonging to the upper and middle classes," which leads to an increase of capital.

The introduction of machinery cannot diminish the demand for labor, nor does it reduce the rate of wages. This follows from the assumption that employment and wages depend on the amount of circulating capital which is increased by technical improvements and which can be easily shifted from one trade to another. All that machinery may do is to force the laborer to change his employment—which is not a "material hardship." [12]

McCulloch further reasons that increased productiveness due to machinery is not the cause of general overproduction or "gluts" in the market. That would be the case only if the demand for things were limited and if the worker exerted all his productive powers. But our wants and desires are insatiable, and "it is absolutely impossible that we can ever have what we should reckon a sufficient supply of all sorts of commodities." [13] On the other hand, as his productive powers increase, the worker is not likely to exert his full powers, but would be able to devote a greater portion of his time to purposes of instruction and amusement.

On the basis of the above analysis, McCulloch comes to the conclusion that "how much soever it may be at variance with the popular opinion," improvements in machinery are always more advantageous to the

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[10] Ibid., p. 479.

[11] J. R. McCulloch, The Principles of Political Economy, Adam and Charles Black, Edinburgh, p. 199.

[12] Ibid., p. 194.

[13] Ibid., p. 191.

laborer than to the capitalist. In particular cases they may reduce the profits of the latter and destroy a portion of his capital, but they cannot, in any case, diminish the wages of the laborer, while they must lower the value of commodities and improve his condition.[14]

The issue was discussed also by Charles Babbage in his work "On the Economy of Manufactures" which appeared in 1832. Babbage explains that the introduction of machinery does not diminish the quantity of labor demanded by the fact that our power to enjoy new things increases our desire for them and this psychology enables us to increase our habitual comforts and to expand production in order to meet new wants. But he stressed (*a*) the effects of new machinery in redistributing the demand for labor so that "considerable suffering among the working classes" results; (*b*) the increased competition for jobs which rationalization induces among workers, and (*c*) the relative difficulties which are created by rapid or gradual improvements; "the suffering which arises from a quick transition is undoubtedly more intense; but it is also much less permanent than that which results from the slower process." Babbage's general conclusion was inconclusive; "That machines do not, even at their first introduction, *invariably* throw human labor out of employment, must be admitted; and it has been maintained, by persons very competent to form an opinion on the subject, that they never produce that effect. The solution of this question depends on facts, which unfortunately have not yet been collected." [15]

JOHN STUART MILL ON MACHINERY AND THE STATIONARY STATE

While the debate on the question of the "Effect of Machinery on the Condition of the Laboring Classes" was going on, economic developments were making the issue of less and less practical importance. The rapid expansion of new industries, the opening up of new areas of the world with increased natural resources, the large migrations from 1825 onward which removed surplus populations from congested areas and declining trades in Europe, proved that for the time being the job-creating possibilities of the new machinery were far greater than its labor-displacing effects.

During the years following the depression of 1837 through the "hungry forties," the distress and misery of the working population in the different industrial countries were ascribed not so much to the labor-displacing influence of the machine as to the general economic and social effects of the new industrialism and of private enterprise. The remedies for the evils were sought in factory legislation, limitation of hours of work, political reform, and social reorganization. The workers' movements of the period were in large part radical in character as evidenced by Chartism in England, the Socialist movements of France and Germany, and by the agrarian and industrial reform movements in the United States.

There is comparatively little discussion in the economic and social literature of these years which bears on the problem under discussion

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[14] Ibid., pp. 196–197.

[15] The passages from Babbage are quoted by T. E. Gregory in "Gold, Unemployment and Capitalism," P. S. King & Son, Ltd., London, 1933, pp. 249–250.

here which is very new. John Stuart Mill restated more fully the classical position though with "some modifications." Mill's argument is based on one of his "fundamental theorems respecting capital," namely that it is the expenditure of capital, and not the demand of purchasers for the product, that gives employment to labor. In his well known phrase—which exasperated Stanley Jevons so much that it caused him to seek a new basis for economic theory—"demand for commodities is not demand for labor." What Mill meant is that consumers through their demand for specific products, determine the direction of labor. But the quantity of labor employed is determined by the amount of circulating capital which is directly applied to the sustenance and remuneration of labor.[16]

Following Ricardo, Mill stresses the different effects which circulating and fixed capital have on the "gross product" of a country upon which the condition of the workers depends. Whether machinery and improvements will injure the interests of the workers depends on whether the increase in fixed capital takes place at the expense of circulating capital. According to Mill, this is theoretically possible. This might happen in a poor country which tried to increase its fixed capital considerably, or it might happen in an advanced country in which capital improvements were undertaken on a very large scale and rapidly. Mill writes:

> All attempts to make out that the labouring classes as a collective body cannot suffer temporarily by the introduction of machinery, or by the sinking of capital in permanent improvements, are, I conceive, necessarily fallacious. That they would suffer in the particular department of industry to which the change applies, is generally admitted, and obvious to common sense; but it is often said, that though employment is withdrawn from labour in one department, an exactly equivalent employment is opened for it in others, because what the consumers save in the increased cheapness of one particular article enables them to augment their consumption of others, thereby increasing the demand for other kinds of labour. This is plausible, but * * * involves a fallacy; demand for commodities being a totally different thing from demand for labour. It is true, the consumers have now additional means of buying other things; but this will not create the other things, unless there is capital to produce them, and the improvement has not set at liberty any capital, even if it has not absorbed some from other employments. The supposed increase of production and of employment for labour in other departments therefore will not take place; and the increased demand for commodities by some consumers, will be balanced by a cessation of demand on the part of others, namely, the labourers who were superseded by the improvement and who will now be maintained, if at all, by sharing, either in the way of competition or of charity, in what was previously consumed by other people.[17]

Nevertheless, Mill did not think that this theoretical possibility was really significant. In actual practice, he did not believe that "improvements in production are often, if ever, injurious, even temporarily to the labouring classes in the aggregate." The reason was that improvements are usually introduced gradually, and seldom, if ever, made by withdrawing circulating capital from production. Improvements are made out of savings, and generally fixed and circulating capital increase together and simultaneously.[18] Even if improvements decrease aggregate produce and circulating capital "for a time," in the long run they tend to increase them. The higher return to capital in profits and the gain to consumers from lower

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[16] John Stuart Mill. Principles of Political Economy, New York, 1877, vol 1, p. 114.
[17] Ibid., p. 134.
[18] Ibid., p. 135.

prices due to improvements lead to an accumulation of capital which can be used for more production and employment.

In advanced industrial countries improvements in production (machinery, etc.) increase total production and employment through their effects on profits and wages. The general tendency of profits is to fall toward a minimum. But this tendency is offset by improvements insofar as the latter extend the field of new employment for capital. This effect is attained, however, only if the improvements do not raise proportionately the habits and requirements of the workers. In that case, owing to the fact that inventions cheapen the article consumed by the workers, money wages will in time be lowered, profits raised, and more capital will be accumulated. On the other hand, if the workers take all the gain from productive improvements in a higher standard of living, money wages will not fall, the fall of profits will not be retarded, and capital accumulation will not be stimulated. What happens, will also depend on the rate of increase of the labouring population.[19]

What is of special interest, in view of recent discussions in this country, are Mill's observations on the "Stationary State." Mill starts out by saying that all political economists had seen that "the increase of wealth was not boundless" and that at the end of the "progressive state" lies the "stationary state" in which there would be no further improvements in the productive arts and no increase in population or capital. The political economists "of the last two generations," say Mill, thought that "an unpleasing and discouraging prospect." But Mill takes the opposite view that such a stationary state "would be on the whole, a very considerable improvement on our present condition."

I confess—

he writes—

I am not charmed with the ideal of life held out by those who think that the normal state of human beings is that of struggling to get on; that the wrangling, crushing, elbowing, and treading on each other's heels, which form the existing type of social life, are the most desirable lot of human kind, or anything but the disagreeable symptoms of one of the phases of industrial progress. The northern and middle states of America are a specimen of this stage of civilization in very favorable circumstances; having, apparently, got rid of all social injustices and inequalities that affect persons of Caucasian race and of the male sex, while the proportion of population to capital and land is such as to ensure abundance to every able-bodied member of the community who does not forfeit it by misconduct. They have the six points of Chartism, and they have no poverty, and all that these advantages seem to have yet done for them (notwithstanding some incipient signs of a better tendency) is that the life of the whole of one sex is devoted to dollar-hunting, and of the other breeding dollar-hunters.[20]

This is not "the social perfection" worth realizing.

In contrast to this, Mill sketches the outlines of the stationary state. "It is only in the backward countries of the world," he says, "that increased production is still an important object; in those most advanced what is economically needed is a better distribution." This object could be obtained by the joint action of "individual prudence" and of "a system of legislation favoring equality of fortunes"—such

[19] Ibid., vol. II, pp. 320–321.
[20] John Stuart Mill, Principles of Political Economy, Fifth London Edition, New York, 1884, vol. 2, pp. 336–337.

as a limitation of the sum which any one person may acquire by gift or inheritance. "Under this twofold influence, society would exhibit these leading features; a well-paid and affluent body of laborers; no enormous fortunes, except what were earned and accumulated during a single life-time; but a much larger body of persons than at present, not only exempt from the coarser toils, but with sufficient leisure, both physical and mental, from mechanical details, to cultivate freely the graces of life." [21]

In Mill's vision, the stationary state becomes the main condition in which the benefit of machinery can be enjoyed by all. It is worth while to quote again his often quoted passage on the subject:

> Hitherto it is questionable—

the passage runs—

> if all the mechanical inventions yet made have lightened the day's toil of any human being. They have enabled a greater population to live the same life of drudgery and imprisonment, and an increased number of manufacturers and others to make fortunes. They have increased the comforts of the middle classes. But they have not yet begun to effect those great changes in human destiny, which it is in their nature and in their futurity to accomplish.[22]

THE MARXIAN ANALYSIS

In the same year which saw the publication of John Stuart Mill's Principles of Political Economy, Karl Marx and Fredrick Engels issued their Communist Manifesto in which the economic and social development of the modern world is sketched as the product of "a series of revolutions in the modes of production and exchange" due to changes in industrial techniques.[23] In 1859, in his Introduction to Capital: A Critique of Political Economy, Marx formulated more clearly the doctrine of economic determinism according to which political, social, and cultural forms grow out of the economic formation of society which, in turn, is shaped by technological changes.[24] These general ideas were applied to the analysis of the processes of capitalistic production and development in Das Kapital (the first volume of which appeared in 1867) in which Marx elaborated his distinctive economic doctrine on the effects of machinery on the status of the worker, on the tendency of capitalistic production to create a permanent "industrial reserve army," and on the inherent forces which underlie the growth of capitalistic economy and tend to transform it into a socialized economic system.

In considering the problem of "machinery and modern industry" in their effects on labor, Marx follows his general dialectical method [25] of

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[21] Ibid., p. 338.
[22] Ibid. p. 340.
[23] Karl Marx and Fredrick Engels, Manifesto of the Communist Party, American edition, Charles H. Kerr & Co., Chicago, p. 14.
[24] One of the clearest formulations of this thesis is given by Marx in a footnote in Capital which reads in part as follows: "A critical history of technology would show how little any of the inventions of the eighteenth century were the work of one single individual. Hitherto no such book has been published. Darwin has aroused our interest in the history of natural technology, that is to say in the origin of the organs of plants and animals, which organs serve as instruments of production for sustaining life. Does not the history of the productive organs of man, of organs that are the material basis of all social organization, deserve equal attention? * * * Technology discloses man's mode of dealing with nature, the process of production by which he sustains his life, and thereby also lays the mode of formation of his social relations, and of the mental conceptions that flow from them." (Karl Marx, "Capital," translated from III German section, Charles H. Kerr & Co., Chicago, 1921, vol. I, p. 406.)
[25] "The central idea in dialectic is that truth and progress are realized through conflict of opposing elements or tendencies." (A. D. Lindsay, Karl Marx's Capital, 1925, p. 17.)

regarding "every historically developed form as a fluid movement.' His treatment of the subject is, therefore, historical and institutional. He traces the historical evolution of the different forms of the division of labor, the development of the manufacturing system and its transformation into modern industry through the application of machinery. He enters into an analysis of the nature of machinery and surveys in some detail the inventions and technical changes which transformed the methods of production in various industries in England and elsewhere and which imparted to them their "capitalistic" character.

His concern is thus with the effects of the machine not in general but in its historical and institutional association with "capitalism," that is, with a system of enterprise based on private ownership and initiative motivated by the desire for profit. Capitalism springs into existence, he writes, "only when the owner of the means of production and subsistence meets in the market with the free laborer selling his labor power."[26] The effects which the machine has on the workers under capitalism spring not from the nature of the machine, but from the way in which it is used by "capital," that is by the employer interested in exchange-value and in "surplus-value." (Profits, Rent, Interest.)

APPROXIMATE EFFECTS OF MACHINERY

It is in this historical-institutional spirit and supported by an extraordinary wealth of testimony drawn from the reports of factory inspectors, parliamentary blue books and other official and nonofficial sources, that Marx draws one of the most stirring indictments ever penned in social-economic literature of modern machine-industry in its "approximate effect" on the workman. Insofar as machinery dispenses with muscular power, he writes, and becomes a means of employing laborers of slight muscular strength and those whose bodily development is incomplete, it enrolls, under the direct sway of capital, every member of the workman's family, without distinction of age and sex. Compulsory work for the capitalist usurps the place, not only of the children's play, but also of free labor at home within moderate limits for the support of the family. By throwing every member of the family on the labor market, machinery depreciates the value of the labor power of the head of the family and "revolutionizes out and out" the contract between employer and worker. "Previously, the workman sold his own labour power, which he disposed of nominally as a free agent. Now he sells wife and child. He has become a slave dealer. The demand for children's labour often resembles in form the inquiries for Negro slaves, such as were formerly to be read among the advertisements in American journals."[27]

Marx dwells in detail, citing statistical evidence, on "the enormous mortality, during the first few years of their life, of the children of the operatives" in England; on the "moral degradation" and "intellectual desolation" of women and children, "artificially produced by converting immature human beings into mere machines for the

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[26] Karl Marx, Capital, vol. I, Chicago, 1921, p. 189—"Capitalist production only then really begins, * * * when each individual capital employs simultaneously a comparatively large number of labourers. * * * A greater number of labourers working together, at the same time, in one place, in order to produce the same sort of commodity under the mastership of one capitalist, constitutes, both historically and logically, the starting point of capitalist production." (Ibid., p. 353.)

[27] Ibid., pp. 431–433.

fabrication of surplus-value"; on the tendency of the machine, "in the hands of capital," to first lengthen the working day "beyond all bounds set by human nature," or, when working hours are shortened by law, to intensify "the exploitation of labor" by "increasing the speed of the machinery and by giving the workman more machinery to tend."[28] He describes the way in which the "wrong use of machinery" in the factory, under capitalist control, transforms the worker into "a part of a detail-machine," a "mere living appendage" of a lifeless mechanism;[29] on the dangers to life and limb of the worker due to unsafe and unsanitary conditions; and, in the final count, on the destruction by the machine of the worker's skill which results in subordinating the now "insignificant individual factory operative to the "master-capitalist in whose brain the machinery and his monopoly of it are inseparably united" and who proceeds to institute in the factory "a barrack discipline"—"a factory code in which capital formulates, like a private legislator, and at his own good will, his autocracy over his own work-people, unaccompanied by that division of responsibility, in other matters so much approved of by the bourgeoisie, and unaccompanied by the still more approved representative system."[30]

THE "STRIFE BETWEEN WORKMAN AND MACHINE"

The "approximate effects" of machinery, destructive as they are, may be offset by legislation; for example, the factory acts with their educational clauses, to which Marx pays high tribute, though he criticizes their shortcomings and stresses the fact that they are the result of "centuries of struggle between capitalist and laborer." But no such remedial action seems possible, according to the Marxian analysis, with regard to the effects of the machine on the employment outlook of labor. In what Marx calls "the strife between workman and machine," the worker is destined to have the worst of it until and unless he can free the machine from its subservience to "capital" and make it the instrument of free producers working cooperatively in a socially motivated economic system.[31]

Marx's analysis of the effects of machinery is closely interwoven with his general economic doctrines—with his theory of value and the formation of "surplus-value" on the one hand, and with his "general law of capitalist accumulation" on the other. His analysis may be conveniently summarized around two points: (1) the criticism of the "principle of compensation," and (2) the theory of a "redundant population" or "industrial reserve army." The ideas centering about these two points, supply what may be regarded as the Marxian analysis of "technological unemployment."

CRITICISM OF THE "THEORY OF COMPENSATION"

A whole series of "bourgeois political economists"—including James Mill, McCulloch, Torrens, Senior, and John Stuart Mill—writes Marx,

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[28] Ibid., pp. 434–450.

[29] "The miserable routine of endless drudgery and toil in which the same mechanical process is gone through over and over again, is like the labour of Sisyphus. The burden of labour, like the rock, keeps ever falling back on the worn-out labourer." (Ibid., p. 462.)

[30] Ibid., pp. 463–464.

[31] "In a communistic society," writes Marx, "there would be a very different scope for the employment of machinery than there can be in a bourgeois society." (Ibid., p. 429; footnote.)

"insist that all machinery that displaces workmen, simultaneously and necessarily sets free an amount of capital adequate to employ the same identical workmen." [32] Marx vents scorn and sarcasm on this "theory of compensation" and on such supporters of the theory as McCulloch and Jean-Baptiste Say for their "pretentious cretinism" and "insipidities." [33] This "optimism of the economists," says Marx, is a travesty on the facts. In reality, employers are driven to introduce machinery and to improve methods of production by their desire to increase the productiveness of labor and to obtain larger profits. The purpose of the machine is to save labor and cheapen the prices of commodities as a means toward enlarging the "mass of surplus-value." If "it costs as much labour to produce a machine as is saved by the employment of that machine, there is nothing but a transposition of labour; consequently, the total labour required to produce a commodity is not lessened or the productiveness of labour is not increased." [34] Marx indicates that there may be other reasons for introducing machinery such as the desire of "capital" to repress strikes, "those periodical revolts of the working class against the autocracy of capital." [35] But the essential and primary reason for the extension of the use of machinery is that of increasing the productiveness of labor by saving the total amount of labor necessary for the production of a given commodity.

The machine thus becomes a "competitor of the workman himself." Modern capitalistic production is based on the sale of labor-power and on specialization which reduces the worker's skill to the handling of a particular tool. When the handling of this tool becomes the work of a machine, the worker's labor-power loses its exchange-value, and "the workman becomes unsaleable, like paper thrown out of currency by legal enactment." The workers made superfluous by machinery either "go to the wall," or swamp the labor-market of other industries, thus reducing wages.[36] The results are aggravated through further disturbances in the rate of wages by the fact that not only the quantity of labor needed to produce the same result is diminished but the character of the labor required is changed by the substitution of less skilled for the more skilled, juveniles for adults, females for males.[37]

No "compensation" can take place because of the effects which the use of machinery has on the division of total capital into its component parts—"constant" capital (i. e., machinery, buildings, raw materials, etc.) and "variable" capital. As more machinery is used, a larger portion of the capital resources of the employer are "locked up" in constant capital, and the portion of variable capital is diminished. But it is variable capital (necessaries of life, such as food, clothing, etc.) which gives employment to labor. The application of machinery thus turns variable capital into constant capital and decreases the funds out of which labor is employed. True, some labor is required to make the new machines, but, in the first place, the total amount of labor is reduced, and, in the second, it is no compensation to workers thrown out of work by the machine.

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[32] Ibid., p. 478.

[33] Marx singles out Ricardo, whom he quotes respectfully on this as on other questions. There is, of course, much similarity in the Marxian and Ricardian analysis of the problem.

[34] Ibid., p. 426.

[35] Ibid., p. 475.

[36] Ibid., p. 470.

[37] Ibid., p. 473.

What is more likely to happen is this: The workers thrown out of work lose their purchasing power; their demand for commodities falls; and if this is not compensated for "from some other quarter," the market price of commodities falls, too. If this condition lasts for some time and extends, capital is displaced in the industries producing the necessaries of life and workers in those industries are also thrown out of work. "Instead, therefore, of proving that, when machinery frees the workman from his means of subsistence, it simultaneously converts those means into capital for his further employment, our apologists, with their cut-and-dried law of supply and demand, prove, on the contrary, that machinery throws workmen on the streets not only in that branch of production in which it is introduced, but also in the branches in which it is not introduced."[38]

This effect of machinery is thus not a "compensation" to the workers, but a "frightful scourge." The displaced workers find they cannot and are not reemployed by the capital which "formerly employed them and which was converted into machinery." If they do find employment, they can do so only through "the intermediary of a new and additional capital that is seeking investment." This means for the workers a process of painful readjustment, competition with workers in other industries and with new entrants into industry, lower wages, and an inferior status. The "economists" claim that the sufferings of the workers displaced by machinery are only temporary ("a temporary inconvenience"), "as transient as are the riches of this world" and that as machinery is applied gradually, the extent of its destructive effects is diminished. "The first consolation," writes Marx, "neutralizes the second." When machinery seizes an industry by degrees, it produces chronic misery among the operatives who compete with it. Where the transition is rapid, the effect is acute and felt by great masses. History discloses no tragedy more horrible than the gradual extinction of the English hand-loom weavers, an extinction that was spread over several decades, and finally sealed in 1838. Many of them died of starvation, many with families vegetated for a long time on 2½ d. a day.[39] In general, the facts show that the "original victims" of the machine, the workers first displaced by it, "for the most part starve and perish."

In the face of the obvious facts of industrial development, Marx cannot deny that the extension of machinery has gone hand in hand with an increase of employment. He insists, however that this has "nothing in common with the so-called theory of compensation." His analysis of the phenomenon is as follows: The use of machinery enables employers to produce not the same but a larger quantity of their produce with fewer workers; this means that there is need for more raw materials and instruments of production. Hence, as the use of machinery extends in a given industry, the immediate effect is to increase production in the other industries that furnish the first with means of production. The increased demand for raw materials also means an increased demand for labor in some of the extractive industries. When machinery is applied to the preliminary or intermediate stages in the production of a commodity, there is an increased demand for labor in the trades using these intermediate products; for example, owing to the abundance of clothing materials produced by machinery there was an in-

[38] Ibid., pp. 480–481.
[39] Ibid., p. 471.

crease in the number of tailors, seamstresses, and needlewomen. Also, as the increase of the means of production and of subsistence is accompanied by a relative decrease in the number of laborers, there is an increased demand for labor in auxiliary industries such as transportation and in new industries such as gas works, telegraphy, photography. Further, as "surplus-value" is increased by machinery, there is an increase in the production of luxuries for "the capitalists and their dependents" and an expansion of foreign trade which leads to an increased demand for labor in the luxury and in the carrying trades. Finally, the extraordinary productiveness of labor makes possible the "unproductive" employment of a larger and larger part of the working class which finds expression in the growth of a "servant class," of the professional occupations, of the class living on rents and interest, and lastly of "paupers, vagabonds, and criminals." [40]

At every point in this process, there are counteracting influences. Thus, as the demand for machinery grows, the machine itself becomes a subject of machine production, a "new type of workman springs into life along with the machine-making industries. In the new industries, the demand is largely "for the crudest form of manual labour." Also, "the place occupied by these branches in the general production is, even in the most developed countries, far from important." [41] In certain industries, an extraordinary extension of the factory system may be accompanied not only by a relative, but by an absolute decrease in the number of operatives employed, as happened in the English worsted and silk factories between 1852 and 1862.

Nevertheless, in spite of displacement by machinery, the number of factory operatives in a given industry may become more numerous than the manufacturing workmen and handicraftsmen that have been displaced, through the building of more mills and the extension of old ones. That is, an absolute increase in the number of workers in the industry is consistent with a relative decrease. This happens during "periods of rest" after technical changes have been introduced into an industry and when there is a mere quantitative extension of the factories on the existing technical basis. Each industry affected by mechanization thus goes through a feverish period which is destructive of the workers and extremely profitable to the employers, but sooner or later enters a "period of rest" which may increase the number of workers and benefit their condition until such period of rest is broken up by a new invasion of machinery.

The same alteration of expansion and contraction characterizes the entire system of capitalistic production after it reaches a certain stage of maturity.

> So soon as the factory system has gained a certain breadth of footing and a definite degree of maturity, and especially, so soon as its technical basis, machinery, is itself produced by machinery; so soon as coal mining and iron mining, the metal industries, and the means of transport have been revolutionized, so soon, in short, as the general conditions requisite for the production by the modern industrial system have been established, this mode of production acquires an elasticity, a capacity for sudden extension by leaps and bounds that finds no hindrance except in the supply of raw material and in the disposal of the produce.[42]

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[40] These concepts reflect the influence of Adam Smith and the classical economists on Marx's thinking (ibid., 487).

[41] Ibid., p. 487.

[42] Ibid., p. 492.

The modern "factory system" satisfies this need for raw materials and outlets by conquering foreign markets and by establishing a new international division of labor to its own advantage.

But this process begets another—namely, the movement in cycles—which accentuates the effects of machinery on the condition of the workers.

The enormous power, inherent in the factory system, of expanding by jumps, and the dependence of that system on the markets of the world, necessarily beget feverish production, followed by over-filling of the markets, whereupon contraction of the markets brings on crippling of production. The life of modern industry becomes a series of periods of moderate activity, prosperity, over-production, crisis, and stagnation. The uncertainty and instability to which machinery subjects the employment, and consequently the condition of existence of the operatives become normal, owing to these periodic changes of the industrial cycle. Except in the periods of prosperity, there rages between the capitalists the most furious combat for the share of each in the markets. This share is directly proportional to the cheapness of the product. Besides the rivalry that this struggle begets in the application of improved machinery for replacing labour-power, and of new methods of production, there also comes a time in every industrial cycle when a forcible reduction of wages beneath the value of labour-power, is attempted for the purpose of cheapening commodities.[43]

In brief, the expansion of employment takes place by spurts and jerks and at best involves occupational shifts and displacements on an extensive scale, in the course of which the workers are "hustled from pillar to post" and "constant changes take place in the sex, age, and skill of the levies." The increase of employment is neither "compensation" for the displaced workers, nor a means of improving their condition. There are periods in the development of capitalism when the growth of capital is more rapid than that of labour-power and when, as a result, wages may temporarily rise. But these are mere interludes. The basic tendency of capitalism is toward a deterioration of the condition of the workers which finds expression in, and is aggravated by, the growth of a "redundant population" or "industrial reserve army."

CAPITAL ACCUMULATION AND THE "INDUSTRIAL RESERVE ARMY"

In his criticism of the "theory of compensation," Marx dealt largely with the short-run effects of machinery, upon the condition of the workers. His theory of the "industrial reserve army" summarizes his views on the long-run effects of machine-industry on "the lot of the labouring class." These long-run effects are determined by the "law of capital accumulation," or the growth of capital, the law which underlies the entire evolution of capitalistic industry and which determines the inherent trend of capitalism toward its own transformation. A statement of the theory of "the industrial reserve army" thus calls for a summary of the Marxian doctrines on the law of capital formation and accumulation.

The starting point of these doctrines is the idea that "the directing motive, the end and aim of capitalist production, is to extract the greatest possible amount of surplus-value."[44] Surplus-value is the increment or excess of exchange-value which the employer receives in the market over the original value which he advances in the pro-

[43] Ibid., pp. [illegible]5–496.
[44] Ibid., p. 363.

duction of his commodity. It is the "unpaid labour"[45] which the capitalist-employer appropriates by paying the worker only for a part of his working-time and only for a part of exchange-value which is embodied in the product of his labour. Surplus-value splits up into various parts, such as profits, interest, merchants' profit, rent, etc., which the employer pays to various individuals who "fulfill other functions in the complex of social production."[46] But it is the industrialist employer who must first appropriate it in its original form, and whose function it is to increase its amount and to provide for its growth.

In performing this function, the industrial employer is limited by certain characteristics of the capital which he has at his command. As indicated above, Marx divides capital into constant and variable.[47] Constant capital, i. e., the instruments of production, raw materials, etc., is merely reproduced in the process of production and does not itself create any new value. It is only variable capital which is devoted to the maintenance of the worker,[48] that has the capacity not only to reproduce itself but to create new value or surplus value.

To obtain surplus-value and to increase its amount, employers must, therefore, increase the amount of variable capital employed. They can do so either by employing more workers or by increasing "the rate of absolute surplus-value,"[49] chiefly by prolongation of the working day. "Free competition" drives every individual capitalist to do his utmost in this respect, and capitalism, as a result, surpasses all earlier systems of production in energy, disregard of bounds, recklessness, and efficiency, as "a producer of the activity of others, as a pumper-out of surplus-labour and exploiter of labour power."[50]

There are limits, however, to these possibilities in the physical endurance of the worker and also in the reactions of society which sooner or later begins to regulate hours of work. But the employer realizes that he can increase surplus-value (or, in Marxian terms, create "relative surplus-value") by decreasing the amount of "necessary labour," that is by increasing the intensity or "the productiveness of labor" so as to make up for the shortening of the duration of working time. This is done by means of machinery and improved methods of production, and the employer is thus impelled, by his hunger for profits and

[45] "All surplus-value, whatever particular form (profit, interest, or rent) it may subsequently crystallize into, is in substance the materialization of unpaid labour." (Ibid., p. 585.) This follows from Marx's labour theory of value which need not be restated here.

[46] Ibid., pp. 618–619.

[47] "That part of capital then, which is represented by the means of production, by the raw material and the instruments of labour, does not, in the process of production, undergo any quantitative alteration of value. I therefore call it the constant part of capital, or, more shortly, constant capital. On the other hand, that part of capital, represented by labour-power, does, in the process of production, undergo an alteration of value. It both reproduces the equivalent of its own value, and also produces an excess, a surplus value, which may itself vary * * * I shall, therefore, call it the variable part of capital, or shortly, variable capital." (Ibid., pp. 232–233.)

[48] "Variable capital is therefore only a particular historical form of appearance of the fund for providing the necessaries of life, or the labour-fund which the labourer requires for the maintenance of himself and family and which, whatever be the system of social production, he must himself produce and reproduce." (Ibid., p. 622.)

[49] The rate of absolute surplus-value is the ratio of surplus-value to the total variable capital, or the ratio of the surplus unpaid labour to the "necessary labour" which is embodied in a commodity and for which alone the worker is paid.

[50] Ibid., pp. 338–339.

by the inexorable laws of "free competition" to convert an ever larger part of his capital into "constant capital."[51]

In his role as organizer and master of the productive process, the capitalist converts as large a part of his surplus-value as possible into capital. The conversion of surplus-value into capital is capital accumulation. It is up to the capitalist, "the owner of the surplus-value" which is produced by the worker from year to year, to decide how much of it he will consume or spend "as revenue" and how much he will save or use as capital for further production. In general, the capitalist has "a passion for wealth as wealth" and is besides under compulsion to accumulate on an ever increasing scale. "The development of capitalist production makes it constantly necessary to keep increasing the amount of the capital laid out in a given industrial undertaking, and competition makes the imminent laws of capitalist production to be felt by each individual capitalist, as external coercive laws. It compels him to keep constantly extending his capital, in order to preserve it, but extend he cannot, except by means of progressive accumulation."[52]

In the early stages of industrial development the capitalist tends to be ascetic and the "capitalist of the classical type brands individual consumption as a sin against his function" of accumulation. But as the progress of capitalist production "creates a world of delights" and opens up, in speculation and in the credit system, "a thousand sources of sudden enrichment," the "modernized" and more educated capitalist develops habits of more luxurious living, which he tries to reconcile with the virtues of accumulation.[53] What happens is that the capitalists become "good livers and men of the world,"[54] while at the same time the production of surplus-value and the accumulation of capital proceed on an ever increasing scale. This is made possible by the growing "productivity of social labour."[55] The increasing productivity of labor increases the mass of surplus-products, and thus enables the capitalist to maintain, or even to increase relatively, his accumulation fund without decreasing his consumption fund. As real wages never rise proportionately to the productive power of labour, an increase in labor productivity enables the employer to set in motion with the same variable capital a larger quantity of labour-power. The

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[51] The employer is in sort of a dilemma: On the one hand, he is eager to enlarge his variable capital and to prolong the working day; on the other hand, he is driven to mechanize and revolutionize industry and to lock up more and more of his capital in machinery or "constant capital" and to accumulate surplus-value by a more intensive use of a relatively decreasing portion of variable capital. Marx was aware of the dilemma involved in his reasoning and tried to meet it in the third volume of "Capital."

[52] Ibid., p. 649.

[53] "When a certain stage of development has been reached, a conventional degree of prodigality, which is also an exhibition of wealth, and consequently a source of credit, becomes a business necessity for the "unfortunate" capitalist. Luxury enters into capital's expenses of representation." (Ibid., p. 651.)

[54] Marx pokes fun at Nassau Senior for "discovering" the doctrine of "abstinence" and at "that queer saint, that knight of the woeful countenance, the capitalist abstainer." (Ibid., pp. 654–656.)

[55] "By increase in productiveness of labour, we mean, generally, an alteration in the labour-process of such a kind as to shorten the labour-time socially necessary for the production of a commodity and to endow a given quantity of labour with the power of producing a greater quantity of use-value." Op. cit., p. 345. As a result of greater productivity, the portion of the working day which goes to pay the worker for the reproduction of his labour-power is shortened, and a larger portion of the working-time accrues to the employer as surplus-value. The productiveness of labour is promoted in the industries which produce the necessaries of life as well as in the industries making the instruments of production and the raw materials, thus making possible a reduction in the cost of living and, hence, in wages. Marx held that "an increase in the productiveness of labour in those branches of industry which supply neither the necessaries of life, nor the means of production for such necessaries, leaves the value of labour-power undisturbed." (Ibid., p. 346.)

growth of labor productivity and improvements in methods enhance the value of capital which is renewed in more effective form as it wears out.[56] Science and technology give capital a power of expansion which is independent of the magnitude of functioning capital, and the production of surplus-value increases more rapidly than the value of added capital. "The more, therefore, capital increases by means of successive accumulations, the more does the sum of the value increase that is divided into consumption-fund and accumulation-fund. The capitalist can, therefore, live a more jolly life and at the same time show more 'abstinence.'"[57]

The accumulation of capital may, under certain conditions, not only bring benefits to the employer, but also improve the condition of the worker. This happens during those "intervals of rest," when the technical basis of industry remains unchanged and when as a result the growth of capital continues while the "organic composition"[58] of capital remains constant. Under such conditions a definite mass of means of production needs the same mass of labour-power to set it in motion. When under such conditions the scale of capital accumulation is extended (owing to special stimuli, such as the opening of new markets or of new opportunities for investment due to new social wants), the variable part of capital is increased, and "the requirements of accumulating capital may exceed the increase of labour-power or the number of labourers." In such case the demand for labor exceeds the supply, and wages may rise. This happened in England in the fifteenth century and again in the first half of the eighteenth century. Under such conditions an increase in the numbers of the working population takes place.

Marx is eager to point out in this connection that "the more or less favorable circumstances" which thus arise for "the wage-working class" do not in any way "alter the fundamental character of capitalist production."[59] The dependence of the workers on capital takes on an "endurable" form, and the workers improve their consumption and living conditions and "can lay by small reserve funds of money." But "a rise in the price of labour, as a consequence of accumulation of capital, only means, in fact, that the length and weight of the golden chain the wage-worker has already forged for himself, allow of a relaxation of the tension of it."[60] Also these "intervals of rest" in which "accumulation works as a simple extension of production, on a given technical basis" become more and more shortened, owing to the operation of the "industrial cycle" and of the basic tendencies of capitalist development.

What is more important, however, is that the growth of capital is accompanied by a change in its "organic composition" which consists in a relative increase of constant capital in proportion to and at the expense of the variable capital. This "law of capital accumulation"

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[56] Marx indicates that the development of productive power is accompanied by a partial depreciation of functioning capital. But, he says that in so far as this depreciation makes itself acutely felt in competition, the burden falls on the worker, in "the increased exploitation of whom the capitalist looks for his indemnification." (Ibid., p. 664.)

[57] Ibid., p. 667.

[58] The "organic composition" of capital, in Marxian terminology, is determined by the proportion of constant to variable capital (or the value of the means of production to the sum total of wages) which, in turn, reflects changes in the technical composition of capital, that is, in the relation of "the mass of the means of production employed" to "the mass of labour necessary for their employment." (Ibid., p. 671.)

[59] Ibid., pp. 672–673.

[60] Ibid., p. 677.

is bound up with the fact that capital growth is stimulated, above everything, by an increase in the productiveness of labor, and the increase in the productivity of labour depends upon the application of an ever larger mass of machinery and other means of production. The progress of accumulation does not exclude the possibility of a rise in the absolute magnitude of variable capital, but it inevitably lessens its relative magnitude.

The change in the "organic composition" of capital is accentuated and accelerated by the processes of concentration and centralization characteristic of capitalistic development. The "smaller capitals" are beaten in the game of competition not only because large scale production is more efficient, but also because the centralization of capital finds a "powerful weapon" in the credit system. While "the relative expansion and energy of the centralization movement is determined to a certain degree by the superiority of the economic mechanism, yet the progress of centralization is by no means dependent upon the positive growth of the volume of social capital. * * * Centralization may take place by a mere change in the distribution of already existing capitals, a simple change in the quantitative arrangement of the components of social capital. Capital may in that case accumulate in one hand in large masses by withdrawing it from many individual hands."[61] By doing so, centralization enables the industrialists to expand the scale of their operations, to develop "socially combined and scientifically managed processes of production," and thus to hasten and extend the revolutions in the technical composition of capital.[62]

The progressive qualitative change in the composition of capital has dire effects on "the lot of the labouring class." Since the demand for labour is determined not by the amount of capital as a whole, but by the amount of variable capital only, that demand falls progressively with the growth of total capital. It is true that as total capital increases, its variable portion also increases, but it increases in a constantly diminishing proportion. In fact, the variable capital diminishes more rapidly than the total capital increases (owing to the effects of increasing centralization and other factors). This means that as total capital grows, and in the direct ratio to the energy and extent of its accumulation, there is produced a "relatively redundant population of labourers, i. e., a population of greater extent than suffices for the average needs of the self-expansion of capital, and therefore a surplus population."[63] This is the law of population peculiar to the capitalist mode of production.[64]

The "surplus labouring population" produced by "the development of wealth on a capitalist basis" becomes in its turn a necessary condition of the existence of the "capitalist mode of production." It forms an "industrial reserve army" which capital uses for its self-expansion. As with the growth of capital and with the development of the credit system industrialists become eager to expand at every possible opportunity, they must have "the possibility of throwing

[61] Ibid., pp. 687–688.
[62] Ibid., p. 689.
[63] Ibid., pp. 690–691.
[64] Marx attacks the Malthusian "principle of population" and argues that the movements of population reflect the changes in the accumulation of capital. See Op. cit., pp. 675–681, 692–693. In his "Principles of Political Economy", Malthus, according to Marx, finally discovered, with the help of Sismondi, "the beautiful trinity of capitalistic production: overproduction, overpopulation, over-consumption—three very delicate monsters, indeed." (Ibid., p. 696, footnote.)

great masses of men suddenly on the decisive points without injury to the scale of production in other spheres. Over-population supplies these masses."[65] Also—

the course characteristic of modern industry, viz. a decennial cycle (interrupted by smaller oscillations), of periods of average activity, production at high pressure, crisis and stagnation, depends on the constant formation, the greater or less absorption, and the reformation of the industrial reserve army of surplus population. In their turn, the varying phases of the industrial cycle recruit the surplus population and become one of the most energetic agents of its reproduction. * * * The whole form of the movement of modern industry depends, therefore, upon the constant transformation of a part of the labouring population into unemployed or half-employed hands.[66]

The production of a relative surplus-population goes on even more rapidly than the technical revolution in production and more rapidly than the diminution in the variable capital as compared with constant capital. This is due to the "absolute interest of every capitalist to press a given quantity of labour out of a smaller, rather than a greater number of labourers, if the cost is about the same," because of savings in overhead costs. The employer achieves his purpose, as already indicated above, by prolonging the working day, by intensifying labor and by replacing skilled with unskilled workers. Thus, one part of the working class is overworked, while the other part is condemned to enforced idleness.

The relative surplus-population, or industrial reserve army, is found in different countries in three forms—the floating, the latent, and the stagnant. The "floating" surplus of labor is found in the centers of modern industry and is composed in large part of young persons who enter industry as boys and who are not given a permanent place in it. The latent surplus population is found largely in agriculture. The stagnant surplus population is formed by groups of labor living below "the average normal level" of the working class who are recruited from decaying branches of industry and who, as a rule, have large families and thus supply "an inexhaustible reservoir of disposible labor-power." Marx illustrates this generalization by reference to miserable living conditions found among some strata of the working population of England and Ireland.

The three forms or elements of the industrial reserve army suffer in varying degrees from the effects of irregular employment—low wages, malnutrition, high mortality, etc. They also act as a drag on the working population as a whole through their effects on wage movements which are regulated by the expansion and contraction of the industrial reserve army. During periods of stagnation and average prosperity, the industrial reserve army weighs down the active labor-army; during periods of over-production and boom, it "holds its pretensions in check." The general effect in the long-run is that "in proportion as capital accumulates, the lot of the labourer, be his payment high or low, must grow worse." The law of capital growth establishes "an accumulation of misery, corresponding with accumulation of capital. Accumulation of wealth at one pole is at the same time accumulation of misery, agony of toil, slavery, ignorance, brutality, mental degradation at the opposite pole."[67]

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[65] Ibid., p. 694.
[66] Ibid., pp. 694–695.
[67] Ibid., pp. 708–709.

As is well known, Marx saw no solution for the problems sketched above except through the transformation of capitalist into socialized production. This ultimate solution was inherent in "the historical tendency of accumulation" itself and was to be realized through the dialectics of capitalist development, that is, the centralization of capital, the conscious technical application of science, socialized labor, and the entanglements of all peoples in the net of the world-market. The climaxing aspects of this process may be described in Marx's oft quoted passage:

> Along with the constantly diminishing number of the magnates of capital who usurp and monopolize all advantages of this process of transformation, grows the mass of misery, oppression, slavery, degradation, exploitation; but with this too grows the revolt of the working-class, a class always increasing in numbers, and disciplined, united, organized by the very mechanism of the process of capitalist production itself. The monopoly of capital becomes a fetter upon the mode of production, which has sprung up and flourished along with, and under it. Centralization of the means of production and socialization of labour at last reach a point where they become incompatible with their capitalist integument. This integument is burst asunder. The knell of capitalist private property sounds. The expropriators are expropriated.[68]

PIONEER INDUCTIVE STUDIES, 1886–99

The last quarter of the nineteenth century was marked by comparative calm in the political and social life of Europe based upon steady economic growth, despite the recurrence of hard times. Economic theory turned to reexamination of its basic premises and began the elaboration of those doctrines of marginal utility and of general and partial equilibrium which were permeated with a spirit of optimism and which tended to see the economic world as a sphere of harmoniously adjusting supply and demand prices. Social reformers, doctrinally stemming from Sismondi, took their first steps toward a practical "solution" of the problem of unemployment which led to the first international conferences on the subject and to the organization of the International Association for the Struggle Against Unemployment. The Socialists began filing away the sharper edges of the Marxian analysis, and though they continued to regard "crises" and an "industrial reserve army" as inherent in and ultimately destined to destroy "capitalism," they devoted their energies to practical measures for the gradual alleviation of unemployment and of other hardships caused by the introduction of machinery.

The main theoretical contributions during this period to the discussion of the problem considered here were largely a further development of the views of Jean-Baptiste Say and of the classical economists. J. E. Cairnes, for instance, in his work on "Some Leading Principles of Political Economy," published in 1874, restated in his own way Say's law, as follows:

> Purchasing power, in the last resort, owes its existence to the production of a commodity, and, the conditions of industry being given, can only be increased by increasing the quantity of commodities offered for sale; that is to say, demand can only be increased by increasing supply.[69]

In restating the wages fund doctrine, Cairnes argues that the "general rate" of wages depends upon three factors—the total capital of

[68] Ibid., 836–837.

[69] J. E. Cairnes, Some Leading Principles of Political Economy Newly Expounded, Harper & Bros., New York, 1878, p. 31.

the country, the nature of the national industries, and the supply of labor. The nature of the industries means largely the relative amount of fixed and circulating capital used in them, and Cairnes reformulates the general theory of classical economics as follows:

> The modifications which occur in the distribution of capital among its several departments as nations advance are by no means fortuitous, but follow on the whole a well-defined course, and move towards a determined goal. In effect, what we find is a constant growth of the national capital, accompanied with a nearly equally constant decline in the proportion of this capital which goes to support productive labor. This is the inevitable consequence of the progress of the industrial arts, the effect of which is to cause a steady substitution of the agencies of inanimate nature for the labor of man.[70]

Cairnes does not deduce from this tendency any pessimistic conclusions. He recognizes that at certain times the progress of wealth and industry may be accompanied by a contraction of the wages fund. This happens when a country undertakes great changes in its industrial structure and does it by "converting circulating into fixed capital. It thus may happen, and, in fact, it has happened, that extensive changes in the character of the industry of a country, even though they be all in the direction of scientific progress, improved processes, and ultimately and even immediately augmented wealth, may nevertheless effect a reduction in the means for supporting productive labor, and may for a time act disastrously on its interests."[71]

But, fundamentally, the results are positive. "It is perhaps superfluous to add," Cairnes writes—

> that it is not to be inferred from the circumstance stated that the progress of those arts is unfavorable to the interests of labor. Even on the lowest and most materialistic view of the interests of labor the reverse is the fact, for what industrial progress under the influence of the advancing arts and sciences effects is a diminution not in the absolute amount of the wages fund but only in the proportion which it bears to the total capital of a country—a diminution which is perfectly compatible with a steadily progressive increase of the fund—

and, therefore, of the demand for labor.[72]

Nevertheless the law of capital growth has serious tendencies. It tends to result in a relative increase of the classes not living by hired labor and in increased inequality in the distribution of wealth. Cairnes thinks, however, that these tendencies may be offset by the action of the laboring population to save and to share in profits. The solution of the labor problem, according to Cairnes, lay in "cooperative industry" on a basis of private ownership.[73]

Even more positive are the views of J. S. Nicholson, whose work on The Effects of Machinery on Wages appeared in 1878. Nicholson singles out and develops the idea of the earlier economists that even the temporary adverse effects of machinery on labor tend to lose in force as the speed with which new machines are introduced and the scale on which the process takes place are lessened. Nicholson claimed that such was indeed the tendency, in accordance with what he described as the "Law of Continuity." According to this law, "a radical change made in the methods of invention will be gradually and continuously adopted"; furthermore, "radical changes tend to give place to advances by small increases of invention." The slowness of introduction of new

[70] Ibid., p. 176.
[71] Ibid., p. 180. [Italics supplied.]
[72] Ibid., p. 176.
[73] Ibid., pp. 274–294.

machines may be due to the inertia of capitalists, to the possibility of improving existing machinery, or to the difficulties of adapting machines to the needs of different trades and industries or to the patent system, but in any case it results in the fact that the rapidity of introduction is less than the mobility of labor. As a result, labor can more easily adjust to the change, and the destructive effects of the machine are greatly reduced.[74]

Nicholson also pointed out that the operation of machinery required general intelligence and skill, and that the machine-making and repairing industries created new types of skill. While he saw a tendency toward industrial concentration as a result of machinery, he held that it was offset by the establishment of new small industries. Furthermore, the adverse effects of machinery on labor could be remedied by factory legislation, trade unionism, and the "growth of higher moral principles." [75]

It was in the United States that a new approach to the problem was made during this period, and the first attempt was made to study the effects of machinery on output and employment inductively. The interest in the problem was enhanced in America as a result of the revolutionary changes which were taking place in industry and of the rapid economic expansion which was accompanied by serious dislocations leading to political and social turmoil. The preoccupations with the problem during these years were reflected particularly in the study by David A. Wells on Recent Economic Changes published in 1889 and especially in the investigations on Industrial Depressions and on Hand and Machine Labor carried out between 1885 and 1898 by Carroll D. Wright, first United States Commissioner of Labor.

Wells' book is an attempt to survey the changes in economic life which were causing so much social upheaval, to examine the causes of these changes, and to appraise the widely held pessimistic views on the future to which they gave rise. Wells proceeds inductively with regard to a wide range of topics. He lists the important discoveries and inventions from 1838 to 1889 which have affected industrial processes and organization. He examines a large number of industries, trades and occupations in which machinery had become dominant, such as cotton textiles, coal mining, making of steel, etc., and quotes figures on the reduction in man-hour requirements per unit of product, or increased output per worker, total production, etc., to illustrate the great strides forward in productivity and producing capacity. He then considers whether this great technical progress can be held to be the cause of the depressions from which the United States and the whole world were suffering and whether it was causing such a displacement of labor as to jeopardize the social and economic future of the workers.

Wells finds that the recent industrial and economic changes are the same in kind as had been going on throughout history. But there was a difference in degree. Also, the cumulative effect of the increasing power to produce was such "that the world * * * for the first time [has] become saturated * * * with the results of

[74] Quoted by George E. Barnett, "Chapters on Machinery and Labor: III. Machinery and the Displacement of Skill," Quarterly Journal of Economics, vol. XL, Nov. 1925. pp. 113–117.
[75] Works Projects Administration, National Research Project, Survey of Economic Theory on Technological Change and Employment, p. 81.

these modern improvements".[76] This has created a serious lack of balance between production and consumption. The world's capacity to produce had developed in the past 15 years in a far greater ratio than the increase in population or its immediate consuming-capacity. One of the difficulties in the situation, according to Wells, was the slow response of the masses of the people to the increased and cheapened production of commodities. Many things, he says, have been showered upon the masses of the people which they don't know how to use and which they don't feel they need and for which they cannot pay the market price. One of the paradoxical results of technical progress is thus "more limited possibilities of new sources of demand throughout the world," and a "larger amount of capital seeking employment"—a condition which is one of the specific causes of the economic depression.

Wells considers in some detail the causes of "the almost universal discontent of labor," which had characterized the recent transitions in the world's methods of production and distribution. The most important causes he lists as follows:

1. The displacement or supplanting of labor through more economical and effective methods of production and distribution.
2. Changes in the character or nature of employments consequent upon the introduction of new methods—machinery or processes—which in turn have tended to lower the grade of labor, and impair the independence and restrict the mental development of the laborer.
3. The increase in intelligence, or general information, on the part of the masses, in all civilized countries.[77]

But these results of machinery are, in Wells' opinion, part of the process of progress, and they are, in fact, more destructive to capital than to labor. "It seems to be in the nature of a natural law," he writes, "that no advanced stage of civilization can be attained, except at the expense of destroying in a greater or less degree the value of the instrumentalities by which all previous attainments have been effected. Society proffers its highest honors and rewards to its inventors and discoverers; but, as a matter of fact, what each inventor or discoverer is unconsciously trying to do is to destroy property, and his measure of success and reward is always proportioned to the degree to which he effects such destruction.[78] And further: "In short, all material progress is effected by a displacement of capital equally with that of labor; and nothing marks the rate of such progress more clearly than the rapidity with which such displacements occur. There is, however, this difference between the two factors involved: Labor displaced, as a condition of progress, will be eventually absorbed in other occupations; capital displaced, when new machinery is substituted for old, is practically destroyed." [79]

Considering all the machinery used in all countries, Wells thinks, the number of persons displaced in recent years by new and more

[76] David A. Wells, Recent Economic Changes, D. Appleton & Co., New York, 1898, pp. 62–63.
[77] Ibid., pp. 364–365.
[78] Ibid., pp. 369–370.
[79] Ibid., p. 373.

effective methods of production does not appear to be so great as is generally supposed. Truly, there is a feeling among the masses that the opportunities for employment are less favorable than formerly, but this is due to the large immigration, the disappearance of public lands, as well as to machinery. The fact is that in the United States, there is little evidence thus far that labor has been greatly disturbed or distressed as a result of the spread of machinery.

Neither is there evidence that—

viewed from the standpoint of 20 or 25 years ago, or before what may be termed the advent of the "machinery epoch" * * * the aggregate of poverty in the world is increasing.[80]

During the last quarter of a century, however, the problem of poverty has been complicated by a new factor, namely, the displacement of common labor by machinery, which has been greater than ever before in one generation or in one country. To what extent the numbers of the helpless poor have been increased from this cause is not definitely known; but the popular idea is doubtless a greatly exaggerated one. In fact, considering the number and extent of the agencies that have been operative, it is a matter of wonderment that these influences in this direction have not been greater. In the United States little or no evidence has yet been presented that there has been any increase in poverty from this cause.[81]

Wells' conclusions as to the future and as to policy are somewhat indefinite. With regard to the future he writes:

There is no reason for doubting that the wonderful material evolution of recent years will be continued, unless man himself interposes obstacles, although the goal to which this evolution tends cannot be predicted or possibly imagined.[82]

But this outlook has its dark side.

It will have to be admitted—

he says—

that the immense changes in recent years in the conditions of production and distribution have considerably augmented—especially from the ranks of unskilled labor and from agricultural occupations—the number of those who have a rightful claim on the world's help and sympathy. That this increase is temporary in its nature, and not permanent, and that relief will ultimately come, and mainly through an adjustment of affairs to the new conditions, by a process of industrial evolution, there is much reason to believe. But, pending the interval or necessary period for adjustment, the problem of what to do to prevent a mass of adults, whose previous education has not qualified them for taking advantage of the new opportunities which material progress offers to them, from sinking into wretchedness and perhaps permanent poverty, is a serious one, and one not easy to answer.[83]

Carroll D. Wright may be regarded as the American pioneer in the inductive and statistical studies both of the business cycle and of labor displacing effects of mechanization. Though his methods of reporting and analysis are crude, he brings together a vast amount of statistical data and makes an effort to classify and interpret them in the light of current social-economic ideas.

In his report on Industrial Depressions,[84] Wright defines the problem in the following words:

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[80] Ibid., p. 432.
[81] Ibid., p. 435.
[82] Ibid., p. 67.
[83] Ibid., p. 437.
[84] This was the first annual report of the Bureau of Labor established by act of Congress, approved June 27, 1884, which provided for the appointment of a Commissioner of Labor by the President. The Bureau was placed in the Department of the Interior, and Carroll D. Wright was the first Commissioner of Labor to be appointed. His first report was published in 1885.

The present industrial depression is the first of its kind as an entirety * * *. History is full of accounts of crisis of various descriptions * * *. Of old, stagnations, when occurring, lasted through long periods * * *. In modern times, we have in the place of the long reaches of the past, short, sharp, and frequent disturbances in the business world.[85]

These disturbances or depressions must be clarified and their causes explained. They are closely related to technical progress on the one hand and to employment of labor, on the other. The connecting link is the increasing power of production, due to machines, with its consequences of overproduction (in relation to "immediate demand"), under-consumption, loss of markets, and unemployment.

Labor displacement is a result of technical progress and an aggravating cause of depressions.

The rapid development and adaptation of machinery in all the activities belonging to production and transportation—

says Wright—

have brought what is commonly called over-production. * * * That labor-saving machinery so-called, but what more properly should be called labor-making or labor-assisting machinery, displaces labor temporarily cannot successfully be denied. All men of sound minds admit the permanent good effects of machinery; but the permanent good effects of it do not prevent the temporary displacement of labor, which displacement, so far as the labor displaced is concerned, assists in crippling the consuming power of the community.

The report then presents statistical data indicating for different industries the amount of labor displaced in recent years. The industries covered are agricultural implements, brick making, boots and shoes, carriages and wagons, cotton goods, metallic goods, paper, pottery, etc. Wright makes the following summary:

The mechanical industries of the United States are carried on by steam and water power representing, in round numbers, 3,500,000 horsepower, each horsepower equalling the muscular labor of 6 men; that is to say, if men were employed to furnish the power to carry on the industries of this country, it would require 21,000,000 men, and 21,000,000 men represent a population, according to the ratio of the census of 1880, of 105,000,000. The industries are now carried on by 4,000,000 persons, in round numbers, representing a population of 20,000,000 only. * * * The figures are only interesting because a condition represented by them is utterly impossible. They are to a certain extent valuable to show the enormous benefits gained by the people at large through the application of improved motive power. They illustrate, too, the extreme view of the displacement of labor, which, as already remarked, has been positive, and, it may well be said, to some extent permanent.[86]

Wright touches upon the question of the distribution of the gains of technical progress—

As a result of machinery—

he writes—

the worker is benefited in increased wages, shorter working time, and higher standard of living, and yet if the question should be asked as to whether the worker received his equitable share of benefits derived from the introduction of machinery, the answer must be "no." His greatest benefit has come through his being a consumer. It is also true that machinery has brought new occupations especially to women, but "there does exist a positive and emphatic over-production, and this over-production could not exist without the introduction of power machinery at a rate greater than the consuming power of the nations involved and of those depending upon their demand." [87]

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[85] Report of the Secretary of the Interior, 49th Cong., 1st sess., House of Representatives. Ex. Doc. 1, pt. 5, 1885, p. 11.
[86] Ibid., pp. 87–88.
[87] Ibid., p. 89.

Wright took up the question of the effects of machinery upon labor upon a larger scale in his report on Hand and Machine Labor.[88] In this study Wright was concerned with a comparison of the "productive power" of hand and machine labor, and the effects of machinery upon labor unit requirements, costs of production, wages, and on the supply of labor.

It is not possible to summarize the contents of these two volumes. The data presented cover a wide range of industries and are significant only insofar as they bear on the practical points at issue. What may be noted, however, are the thoroughness with which the study was planned, the care with which the samples were selected, the manner in which the trades and occupations were broken down into processes and operations, the methods of timing them, and the general spirit of objectivity in which the inquiry was conducted. It is a monument to Wright's constructive work in the field of industrial and economic reporting.

Wright summed up the results of these studies in his book on the Industrial Evolution of the United States.[89] He contrasts the dual influence of machinery on labor, the "displacement of labor," and the "expansion of labor." His conclusion is that the latter is far more important in its effects than the former. He also stresses the "ethical influence of machinery on labor"—the tendency of the machine to diversify employment, to reduce working time, to improve living standards, and to extend the facilities for the education of the masses.

[88] Thirteenth Annual Report of the Commissioner of Labor, 2 volumes, 1898; Washington, 1899.

[89] Carroll D. Wright, The Industrial Evolution of the United States, 1895.

CHAPTER II

TWENTIETH CENTURY PROBLEMS

NEO-CLASSICAL THEORY AND ITS CRITICS

In the history of social-economic thought and policy, the decade and a half preceding the first World War—the years 1900–14—may be regarded as a period of transition from the nineteenth to the twentieth century. It was during these years that the new postulates, methods, and concepts of economic theory, associated with the work of Jevons, Alfred Marshall, John B. Clark, the Austrians and of the Lausanne School, were elaborated by numerous followers and were combined into a system of "neo-classical economics" which was to be the dominant school of economic thought.

Insofar as the relation of technology to employment was conceived, the representatives of this school during this period saw no serious problems: On the whole, they harked back to the optimistic views of Jean-Baptiste Say and the English "classicists," which were now reinforced by the concept of "economic equilibrium." In Marshall's Principles of Economics the word unemployment does not occur, and his references to "discontinuous" employment are few and unimportant. In general, though in his own way, he restates the "theory of compensation." The general assumption is that all factors of production, while competitive in a degree, are primarily complementary and "constitute the field of employment for each other." [1] This means that as the efficiency of capital or labor is increased, the earnings of the other is enhanced. Thus—

> if the supply or efficiency of business ability increases, there is likely to be some displacement of manual labor by new contrivances for economizing effort, and by new inventions of various kinds. But this shrinking in some directions of the field of employment for manual labor will be more than compensated in others * * * In like manner, an increase of material capital causes it to push its way into new uses; and though in so doing it may occasionally diminish the field of employment for manual labor in a few trades, yet on the whole it will very much increase the demand for manual labor and all other agents of production.[2]

This takes place through the increase in national income which, owing to a fall in the rate of interest, is divided more in favor of labor than before. The increased demand for labor will come from new industries and from the makers of new and more expensive machinery in all branches of production.

In general, Marshall thought that "the inconstancy of employment in modern industry is apt to be exaggerated." [3] Though the rapidity of invention, the fickleness of fashion, and above all the instability

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[1] Alfred Marshall, Principles of Economics, Second Edition, 1891, p. 709.
[2] Ibid., p. 710.
[3] Ibid., p. 736.

of credit, do certainly introduce disturbing elements into modern industry; yet * * * other influences are working strongly in the opposite direction, and there seems to be no good reason for thinking that inconstancy of employment is increasing on the whole.[4] These other counteracting influences were of an economic and social character which tended to raise the standard of life, which in turn tends to increase the national dividend for the whole population as well as for different groups.

The theories of the neo-classical economists on the effects of technical progress on the demand for labor have been ably presented in some detail in the Survey of Economic Theory on Technological Change and Employment already referred to.[5] The presentation of the Survey" is briefly summarized and restated in the following pages.

The neo-classical theory rests on the concept of economic equilibrium. An equilibrium condition is—

> one in which all factors of production, including labor, are fully employed * * * and are employed in a manner that is the best paying to everyone concerned, thus precluding all incentive to a change. The several producers, that is, the entrepreneurs whose decisions determine the pattern of production and employment, use the several factors of production—say, capital and labor—in proportions which pay them best; and they pay for them at a rate corresponding to the value of their respective marginal products so that there is no incentive for the entrepreneurs to depart from those proportions. There is likewise no incentive for those who supply those factors of production—investors or workers—to shift from one field of employment to another since the marginal product of the several factors of production is the same in all fields and so is, accordingly their remuneration.[6]

It is possible to conceive that an economic society, having attained a condition of equilibrium, should continue in such a condition indefinitely. Such a condition of "static equilibrium" would mean that there would be no further change in price relationships either between the commodities or between the factors of production. There would be—

> no change in the apportionment of resources between the several fields of production, as well as none in the comparative shares of the several factors either in production or in the distribution of the product. In such a state the prices of the several factors of production are equal to the value of their marginal net products, and the sum of the prices of all the goods and services produced is equal to the sum of the remunerations of all the factors.[7]

In such a "static equilibrium" there can be only oscillations around the point at which equilibrium is maintained. "Equilibrium economics" is largely concerned with the analysis of the price relationships and price mechanisms which equate or "equilibrate" supply and demand under such abstract and hypothetical static conditions. In a dynamic society there is movement from one condition of equilibrium to another. The forces which disturb a given equilibrium and bring about a shift to another are the increase of population, increase of capital, improvements in methods of production, changes in industrial organization and the growth of consumers' wants. But the forces which disturb equilibrium also set in motion forces which tend to establish a new equilibrium position. We thus have a "moving equilibrium" which means that the economy is at one and the same time "gravitat-

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[4] Ibid., p. 737.

[5] Work Projects Administration, National Research Project, Survey of Economic Theory on Technological Change and Employment by Alexander Gourvitch, May 1940.

[6] Ibid., pp. 84–85.

[7] Ibid., p. 85.

ing" toward a given equilibrium and readjusting itself to dislocations in a new equilibrium position.

The processes of adjustment and readjustment are automatic and take place through the several price mechanisms and the principle of substitution.

> In any given situation there is always a theoretical set of prices for all goods and services which are either on the market or in process of coming on the market, at which supply and demand would be equal and which would be adequate to cover the costs of production; and that equilibrium price structure comprises a relationship between prices of the several factors of production—between the wage rate and the interest rate—such as would assure full employment of all factors.[8]

There can thus be no general overproduction of commodities. Neither can there be, in the long run, unemployed labor any more than there can be unemployed capital. There is in any situation a rate of wages and a rate of interest at which all labor and all capital will be employed. If there is unemployment, it is proof that wages are above the equilibrium level—that is, too high in relation to the marginal productivity of labor.[9] The unemployment results because, under such conditions, capital is substituted for labor either through changes in industrial organization or through a shift of investments to industries employing relatively less labor. But the unemployment thus created tends to lower the wage level, while as more capital is substituted for labor its profitability (marginal productivity) will decrease and its price (or interest rate) will rise. These developments will check the further substitution of capital and stimulate the reemployment of labor. Inversely, a fall of wages below the equilibrium level will bring about a substitution of labor for capital; such substitution will be checked in time by the resulting rise in wages, declining marginal productivity of labor and the decline in the interest rate.

Considering technological change, in particular, its first effect is to cause dislocations in employment. But it results at the same time in a reduction of production costs, which means that some of the physical and economic resources, previously used in production, are set free and may be used to increase production elsewhere. These resources can be used since the aggregate purchasing power of the community is not impaired. These resources will generally be used. "As long as they are not * * * used, the best-paying combination is not present, and it is the quest for that combination that carries a tendency toward a new equilibrium position."[10] Thus technological change while disturbing the economic equilibrium insofar as employment is concerned, sets into motion forces which tend to restore the full employment of labor.

This tendency toward readjustment through lower costs and increased production meets no obstacles either in the possibilities of market expansion or of capital supply. According to neo-classical theorists, increased production means increased aggregate purchasing power and demand. Through the movements of wage and interest rates, capital accumulation adjusts itself to technical changes. The processes of technical change, increasing wealth, capital saving, and

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[8] Ibid., p. 86.

[9] It follows from this that unemployment can always be diminished by a lowering of wage rates.

[10] Work Projects Administration, National Research Project, Survey of Economic Theory on Technological Change and Employment, 1940, p. 91.

employment tend to keep in step, thus making for harmonious development and progress. The dislocations caused by technical changes—such as disproportion in production, displacement of labor, etc.—are temporary, and are easily taken care of through the automatic operation of the delicate and intricate but nonetheless effective mechanism of prices.

In contrast to the elaboration of neo-classical and "equilibrium" concepts was the decided step forward taken in the development of the doctrines dealing with economic fluctuations, depressions, and inductive methods in the "crises." Aftalion, Tugan-Baronawski, Lescure in Europe and especially Wesley C. Mitchell in this country gave precision to the idea of periodic cyclical movements in economic life and inaugurated the descriptive and analytical study of the "business cycle" which was to exercise such an important part in economic thought and social policy after 1918.

While neo-classical theories were predominant, especially in academic circles, they had their critics who exercised considerable influence on thought and policy. The most important among them were perhaps John A. Hobson in England, and Thorstein Veblen in the United States. These two writers may be regarded as having reinterpreted the doctrines of Sismondi and Marx, being thus closely related to the neo-liberal and neo-marxian trends of thought of the day. Hobson stressed the shifts in the distribution of the labor supply caused by machinery and the influence of machinery on industrial depressions through its stimulation of "oversaving" or (what is the same) the intensification of "underconsumption." Veblen gave brilliant expression to the idea that technological progress must accentuate the opposition between the "machine process" and "business enterprise" and must involve the latter in ever more acute conflict with the needs for the preservation of capital, full employment of economic resources, and the development of social and economic values.

Both neo-classicists and their critics had a part in the making of policies with regard to unemployment. Sir William H. Beveridge, an able representative of neo-classical economics, influenced policy through his important volume on Unemployment: A Problem of Industry.[11] On the other hand, representatives of the dissident schools (Sidney and Beatrice Webb, John R. Commons, Charles Gide, and others) played an active part in the movements for specific legislative measures against the evils of unemployment.

Despite theoretical differences, the general trend during these years was to minimize the importance of "technological unemployment" as the term has since been interpreted. The causes of unemployment held to be important were those inherent in the frictions of the economic system—seasonal variations, cyclical fluctuations, immobility of labor, etc. The remedies sought dealt, therefore, with improvement of the internal structure of plants and industries, the elimination of seasonal variations in production, and with bettering the organization of the labor market. The outstanding legislative achievements of these years in this field were the establishment of the system of Labor Exchanges in England and the first steps toward unemployment insurance in a number of countries.

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[11] First published in 1909; new edition, Longmans, Green and Co., London, 1930.

PROSPERITY AND TECHNOLOGICAL UNEMPLOYMENT IN THE UNITED STATES, 1924–29

By 1924, interest in problems of cyclical unemployment was more or less on the wane. The wave of prosperity which had begun in 1922 gave a new turn to economic discussion. Broadly, three main currents of ideas may be distinguished which had a direct bearing on industrial and labor problems. One reflected the optimism of those who saw a "new era" in American economic life—an era of continuous prosperity—rising to ever higher levels, steady in its progress owing to "the ironing out" of industrial fluctuations, and socially stable, thanks to higher wages, a wider distribution of wealth, and the growing "good will" in the relations of employers and workers. In the light of these ideas, there could be but little concern with problems of unemployment. Interest in the effects of the machine was largely in terms of its effects on wages and on the future of the labor supply.[12]

Another current was fed by the post-war interest in the influence of monetary and banking policies upon price relations and upon economic balance and grew out of the "new art of central banking" stimulated by the Federal Reserve Board in the United States and by the central banks abroad. The discussion centered around the possibility of using the new devices of central banking—the rediscount rate and open-market operations—to achieve a stabilized price-level which was presumably desirable as a means for steadying business activity. This discussion led to a new emphasis in economic thinking on the importance of the monetary and credit mechanism for industrial activity and prepared the ground for some of the ideas and proposals which were to be advanced during the years after 1929, with regard to employment and unemployment.

The third current of thought flowed directly out of the efforts of organized labor to adjust to the new industrial developments. The main element in this current of thought was the emphasis on the "new industrial revolution" which was taking place in the United States, on the unprecedented growth of productive power and labor productivity which the revolution was bringing in its trail, and on the consequences which these industrial developments were having on the status and economic welfare of the workers.

The discussion aroused by these issues went through two stages. Between 1922 and 1926, the problem which was debated most was that of the distribution of the gains from the new increase in productivity—essentially its effects on wages. It was at its convention in 1925 that the American Federation of Labor came out with its theory of the "social wage" according to which labor, as a contributing factor to the increase of productivity, should share in the benefits through increased wages. It was partly in connection with these discussions (though also in large measure owing to the war experience which stimulated the development of economic research here and abroad) that the problem of measuring production and productivity began to attract attention and that the first important steps

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[12] See for example, George E. Barnett, "Chapters on Machinery and Labor. IV. The Introduction of Machinery and Trade-Union Policy," Quarterly Journal of Economics, vol. XL, February 1926, pp. 209–231.

were made in this direction.[13] Emphasis in the studies made by the Bureau of Labor Statistics was on labor productivity in relation to labor costs and wages.[14]

Between 1927 and 1929, the emphasis shifted to the effects of the "new industrial revolution" on employment. This change was due to several factors—the growing concern with the condition of surplus labor in the "sick" industries—coal mining, textiles, railroads; the disappearance of old skilled trades; the rapid growth of new occupations, and in some measure, also to the influence of European conditions and experience on American thinking. Perhaps, the most important influence was the situation in a few industries, such as cigar making, coal mining, railroads, machinery, in which rapid mechanization in combination with such other factors as wartime overexpansion, high wage rates, and rigid trade union policies, was responsible for large-scale displacements of labor. A contributing factor were the new personnel policies of management which, while aiming at lowering labor turn-over and at greater stabilization of employment, were alleged to involve the disemployment of older workers—the "men over forty."

Largely, owing to the influence of organized labor, the generalization became current that, despite so-called prosperity, there was a large amount of unemployment in American industry due to mechanization and to technical changes. The term "rationalization" which had become current in Germany as a result of similar developments, was at first used to designate the new problem. But the term "technological unemployment" was soon coined and became common currency.[15]

The study of the "new problem" took three main forms. First, various government departments and private agencies made attempts to estimate the total number of unemployed on the basis of available data which were very meager indeed. These efforts gave the impetus to the various unemployment surveys and censuses which were to follow.

Second, a series of statistical investigations were begun of the changes in labor productivity and of the displacement of labor by machinery in specific industries.[16] Labor productivity was measured in these studies by dividing volume of output by the number of employees (or an index of output by an index of employment). This was a measure of productivity per worker, but it was realized that it would be desirable to obtain data for computing output per man-

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[13] E. E. Day, W. M. Persons, and E. D. Coyle, "An Index of the Physical Volume of Production," Review of Economic Statistics, September 1920–January 1921; Walter W. Stewart, "An Index Number of Production," American Economic Review, March 1921; E. E. Day and Thomas, The Growth of Manufacturers, U. S. Census Bureau, Monograph No. IX, ch. I and II and appendix A.

[14] See U. S. Bureau of Labor Statistics, articles in Monthly Labor Review, January 1923: "Labor Efficiency and Productiveness in Sawmills"; November 1924: "Labor Productivity and Costs in Certain Building Trades"; September 1926: "Labor Productivity and Labor Costs in Cotton Manufacturing," Bulletin N–407, published in 1926; "Labor Cost of Production and Wages and Hours of Labor in the Paper Box Board Industry," Bulletin No. 360: "Time and Labor Costs in Manufacturing 100 Pairs of Shoes," 1924.

[15] No one seems to lay claim to priority in the use of the term.

[16] See U. S. Bureau of Labor Statistics, Monthly Labor Review for April 1937; "Displacement of Labor by Machinery in the Glass Industry"; May 1927: Comparison of Employment and Productivity in Manufacturing Industries, 1919–25; September 1927: Article by J. J. Davis, "Productivity of Labor and Industry"—"The Problem of the Worker Displaced by Machinery"; March 1929: By Ethelbert Stewart, "Ultimate Effects of Automatic Machine Production." Also a series of articles during 1928–29 on Stability of Employment in Specific Industries such as automobiles, iron and steel, men's clothing, etc.; and several bulletins on labor productivity in selected industries, e. g., Bulletin N–441 by Boris Stern: "Labor Productivity in the Glass Industry."

hour. Displacement was conceived as a process of direct discharge of workers as a result of improvements in existing machines or of the introduction of new machines.

The third approach to the problem was made in several studies which aimed to find out by the sampling method, through questionnaires and interviews, what became of displaced workers, how soon they were reabsorbed into industry, and in what way.[17] These studies were significant in that they disclosed the fact that, in a large proportion of cases, labor-saving devices resulted in unemployment of considerable duration and that the process of finding a new job was accompanied by hardships, in many cases by a lowering of the worker's industrial status and earning capacity.

It should be evident from the material presented above—

wrote Dr. Lubin—

that there is considerable mobility of labor at the present time and that the newer trades are absorbing a good percentage of the workers who are being discharged from the "older" industries. Absorption, however, is a relatively slow process. Those workers who do find new jobs are in a majority of instances compelled to remain idle for 3 months or more before finding new employment. When they do secure new jobs, they frequently take them at a sacrifice in income. An appreciable portion of them, however, have been able to secure higher earnings in their new jobs than in their old.[18]

The discussions of these years led to the hearings on unemployment held by the Committee on Education and Labor of the United States Senate, of which Robert F. Wagner was chairman.[19] These hearings stimulated national interest in practical proposals for alleviating unemployment and gave the impulse to the legislative efforts which culminated several years later in the passage of th Social Security Act.

The prevailing ideas of these years found their most elaborate expression in the culminating economic document of the period—the report on "Recent Economic Changes in the United States."[20] The two volumes of the report mirror both the optimism and puzzlement of a country overwhelmed by extraordinary industrial developments which brought in their trail a mixture of prosperity and hardships, of economic growth and decay, of stability and unbalance. The individual writers of the various sections of the report reflect mixed ideas and attitudes ranging all the way from an unqualified optimistic faith in American initiative, ingenuity, versatility and mastery[21] to a cautious acceptance of the blessings of the present with faint misgivings of the dangers lurking in the future.[22]

The problem of unemployment is treated in the report in this general spirit. The basic premise on which the treatment of the problem proceeds is that the industrial developments of 1922–29 were not revolutionary in character and differed from similar changes in the past only "in speed and spread." "Acceleration rather than struc-

[17] I. Lubin, "The Absorption of the Unemployed by American Industry," Brookings Institution, 1929; and "Measuring the Labor Absorbing Power of American Industry" in Journal of American Statistical Association, March 1929; R. J. Myers, "Occupational Readjustment of Displaced Skilled Workers" in Journal of Political Economy, August 1929.

[18] I. Lubin, "Measuring the Labor Absorbing Power of American Industry," Proceeding, American Statistical Association, 1929, p. 32.

[19] U. S. Senate, Committee on Education and Labor: Unemployment in the United States; hearings, December 11, 1928, February 7, 1929, etc. (70th Cong., 2d sess.).

[20] Recent Economic Changes in the United States, Report of the Committee on Recent Economic Changes, of the President's Conference on Unemployment, Herbert Hoover, chairman, 2 volumes, McGraw Hill, New York, first edition, 1929.

[21] See Introduction by Edwin F. Gay, vol. I, pp. 1–2.

[22] "A Review" by Wesley C. Mitchell, vol. II, pp. 841–910.

tural change," reads the report, "is the key to an understanding of our recent economic developments. Gradually the fact emerged during the course of this survey that the distinctive character of the years from 1922 to 1929 owes less to fundamental change than to intensified activity.[23] The report makes some attempts to measure the rate of acceleration, but without being conclusive.

It is difficult—

the report reads—

to measure the technical progress of 1922–27, with the data now available. It is still more difficult to make reliable measurements for earlier years, when censuses were taken at longer intervals and fewer supplementary figures were published. But doubts whether the rate of improvement in the past 6 years is unprecedented are not of great moment. It remains clear that the industrial revolution is not a closed episode; we are living in the midst of it, and the economic problems of today are largely problems of its making.[24]

The industrial changes between 1922 and 1929, which the report emphasizes, are the growth of many new industries and the great increase in productivity or output per worker, due to various factors (industrial research, new processes and materials, greater use of power machinery, etc.). On the whole, economic relationships and social institutions kept step with underlying technical and industrial changes. Mass production was accompanied by the growth of mass consumption due in large measure to the acceptance of the principle of "high wages" by employers; price relationships and movements showed balance and stability due to effectiveness of the monetary and banking system and to a greater reliance of the American economy on internal forces and markets; the development of the service industries and the greater use of leisure due to a shortening of hours of work raised living standards and added grace to American life.

There were some maladjustments which caused hardship to one or another of the groups of the population, and among them the report singles out as of special importance the effects of technical progress on the workers. There is not complete agreement, however, among the contributors to the report as to the gravity of the problem. One of the authors, for instance, merely states the opposing views held on the effect of the new techniques on skill and employment and withholds any definite conclusion.

The thing that is certain is that our information concerning the extent, nature, and reasons of unemployment in this country is inadequate. The inadequacy of public information is, unfortunately, equaled by the inadequacy of information in individual companies. Few of them know exactly what numbers have been released or transferred on account of technical improvements, and almost none knows anything about what has happened to the men who were released.[25]

In the chapter on Labor,[26] a step forward is made in clarifying the meaning of labor productivity and its measurement, and in defining and estimating unemployment in the United States. With regard to productivity of labor, the writer of the chapter says:

The measures of the per capita output of labor considered in this section are not measures of the specific productivity of labor. They are the results of comparisons between the total physical output of industry and the number of

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[23] Recent Economic Changes, vol. I, p. IX.
[24] Ibid., vol. II, p. 863.
[25] Henry S. Dennison in chapter on Management, vol. II, p. 514.
[26] Leo Wolman, Labor, ch. VI, vol. II, pp. 425–493.

wage earners employed in producing it. . . . But statistics of man-hours are not available until very recent times and then only for a limited number of industries.[27]

The report indicates the factors which may influence per capita output:

Changes in the per capita output of labor, as in total output, may clearly be due to a variety of factors. In the long run, the levels of education and skill of the working population of a country, the growth of capital and the use of machinery, the alertness and ingenuity of management, and the state of science may determine both the direction and the rate of change of industrial production. During shorter periods, accidental or abnormal factors, such as apparently operated from 1916 to 1921, like sudden changes in the length of the workweek, marked variations in the efficiency of labor, resulting either from the state of mind of the workers, from the carelessness of management, or from the replacement of experienced workmen, may conceivably not only interrupt the prevailing trend of production, but also change its direction. The segregation and weighing of all these factors, or even of the most important of them, are not possible in the present state of knowledge. The most that can be done is to appeal to reasonable hypotheses and to informed common knowledge.[28]

The problems of method involved in computing per capita output are stated in some detail:

Both of the elements of the formula for deriving per capita output have serious, if irremediable, defects. The measures of the total output of industry are better for the mining and transportation industries than they are for manufacturing and agriculture; and they do not include the highly important construction industry, for which there are no satisfactory statistics of either physical output or employment. They cannot, by their very nature, take into account changes in the character and quality of the products of industry. Since the statistics of the production of raw materials or of commodities in their early stages of fabrication are more numerous than statistics of highly fabricated goods, the measures are too heavily weighted for raw materials and, consequently, underestimate the rise in total output. In general, there is less material for the new and growing industries than for the old established ones, whose rate of growth has probably already slackened before the compensating influence of the growth of the young industries can make itself felt in the measure of total output. And it is, finally, not always certain that the changing importance of industries is adequately allowed for in the weights used for the computation of average changes in total production.

The employment indexes are probably superior for the manufacturing and transportation industries than for the rest. For manufacturing they are much more reliable in the later than in the early years, although one important series, that of the United States Bureau of Labor Statistics, appears to exhibit a downward bias even during the latest years. All of the series, finally register the amount of work done by the number of people employed and not by the time worked, and this procedure, as it has already been indicated, may involve misleading conclusions.

The commodities that enter into the aggregate production of a country cannot all be recorded in the same unit. The simplest method of reducing all goods to a common denominator is to express them in pecuniary units. Variations in the resultant aggregates, however, would then reflect changes both in physical output and in prices. Correction for price changes, for many well-known reasons, raises as many problems as it solves. Resort must then be had to the device of the index number, which is an average of the measures of relative changes in the items of a heterogeneous series. In place of aggregates of incommensurable units, such as bushels, feet, tons, trucks, and so on, the index number registers the weighted average of all changes in the number of units of output of the commodities under consideration. Even the construction of index numbers involves the difficult problem of discovering the importance of each industry, so that the changes in the output of each product may be properly weighted.[29]

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[27] Ibid., pp. 446–447.
[28] Ibid., p. 447.
[29] Ibid., pp. 447–448, footnote 25.

The writer does not enter into an analysis of the causes of changing productivity. The factors are "hard to disentangle and, when separated, to measure. Even such an apparently simple concept as the mechanization of industry," he says, "does not yet lend itself to satisfactory statistical analysis." [30] Neither does he enter into a consideration of the types and causes of unemployment, being content to present a "new estimate of unemployment" based on more careful statistical methods.

The position of the writers of the report with regard to the question of technological employment (which is put in quotation marks) is summed up in a section of the final review,[31] which reads in part as follows:

> Among all the hardships imposed by increasing efficiency, most publicity has been given to the decline in the number of wage earners employed by factories. That is a matter of the gravest concern in view of the millions of families affected or threatened by the change, and in view of their slender resources. To it special attention has been paid in this investigation.
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> The new phrase coined to describe what is happening, "technological unemployment," designates nothing new in the facts, though the numbers affected may be large beyond precedent. Ever since Ricardo shocked his rigid disciples by admitting that the introduction of "labor-saving" machinery may cause a temporary diminution of employment, economists have discussed this problem. Granting Ricardo's admission, they have nevertheless held that, in the long run, changes in method which heighten efficiency tend to benefit wage earners. English experience since Ricardo's day seems to bear out this contention. The power looms, which put an end to hand-loom weaving after tragic struggles, have not reduced the number of British workers employed in weaving, or cut their average earnings. The railways, which displaced the old mail coaches and carters, have not reduced the number of transport workers or made them poorer. And the new trades of building and caring for the elaborate modern equipment must not be forgotten. There doubtless are cases in which improvements in methods have caused what promises to be a permanent reduction in the number of persons employed in an industry. By defining industry narrowly, these cases can be made numerous. But the broad result plainly has been that the industrial triumphs of the nineteenth century increased the demand for labor and increased its rewards. "Labor-saving" machinery has turned out to be job-making machinery.
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> To recall these familiar facts (the Review continues) should not diminish by one jot our rating of the hardships suffered by men who are thrown out of jobs. They and their families often undergo severe privation before new employment can be found; the new jobs may pay less than the old or be less suitable; too often the displaced man never finds a new opening. Technical progress is continually made at cost to individuals who have committed no fault and committed no avoidable error of judgment. No organized plan has been evolved for preventing such hardships, aside from the schemes devised by some trade unions for tiding their members over mechanical revolutions in their crafts. The nations have left the remedy to "natural forces"; they have trusted that the expansion of production, which improvements bring about, will presently open new places for the displaced workers.[32]

The extent of displacement and reabsorption during the period is summed up as follows:

> All these data are estimates of the net changes in numbers of persons "attached to" the occupations in question. They show that American wage earners met "technological unemployment" in manufacturing mainly by turning to other ways of making a living. The decline from 1920 to 1927 in the number of persons actually at work in manufacturing enterprises is put at 825,000, but the number of unemployed among the people who depended on factory work for a living increased only 240,000 between 1920 and 1927, according to the best figures available. If these estimates are approximately correct, then some 585,000 of the

[30] Ibid., p. 461.
[31] Written by Wesley C. Mitchell.
[32] Ibid., pp. 876–877.

workers laid off by factories had taken up other occupations. That is, 71 percent of the workers displaced had attached themselves to new trades by 1927.

Adopting a new occupation, however, does not guarantee getting a new job. The surplus workers from our farms and factories who hunted for fresh openings increased unemployment in other fields. The expansion of business, particularly the expansion of miscellaneous and mercantile occupations, made places for perhaps four and a half million new wage earners. But the supply of new jobs has not been equal to the number of new workers plus the old workers displaced. Hence there has been a net increase of unemployment, between 1920 and 1927, which exceeds 650,000 people * * *.

One may wonder at the versatility, initiative, and mobility of Americans, as evidenced afresh by their prompt shifting of occupations on so great a scale in recent years. One may wonder also at the rapid expansion of the trades which have absorbed some 5,000,000 employees in 7 years without reducing wage rates. But one must not forget that these shiftings have been compulsory in large measure; men have been forced out of farming and forced out of factories as well as pulled into automobile services, shops, and restaurants. And the employment balance is on the unfavorable side. While our economic progress has meant larger per capita earnings for all workers taken together, it has imposed severe suffering upon hundreds of thousands of individuals.[33]

In the nature of the report, no concrete proposals for dealing with the problem were in order. An interesting suggestion, however, is made by Henry S. Dennison to the effect that the crucial factor in the problem may be the rate of inventions of new consumers' goods as compared with the rate of inventions of machines and new manufacturing processes.

TECHNOLOGICAL CHANGE AND THE DEPRESSION, 1929–33

During the "great depression" interest again shifted to the cyclical aspects of the unemployment problem. An ever larger place in the discussion of these years was occupied by theories as to the origin and causes of cyclical fluctuations and by proposals for dealing with such unemployment (public works, monetary reflation, price and wage policies, economic planning, etc.). The relation of technical change to unemployment was examined more clearly from the point of view of the part which technical improvements play in the development of the business cycle. On the other hand, the long term significance of the technological factor was stressed by the advocates of technocracy and economic planning.

The discussion of the problem during these years centered around the issues of the "compensatory theory," the social effects of technology, the methods for alleviating the hardships due to occupational displacements, aid the need for obtaining more information on the subject. Whatever advances were made in the thinking on the subject may best be brought out by considering the writings of those years.

THE RESTATEMENT OF THE COMPENSATORY THEORY

While the idea of technological unemployment loomed large in the public mind, professional economists, by and large, continued to uphold the "compensatory principle" according to which workers displaced by technical improvements sooner or later were reemployed owing to the industrial expansion due to these improvements. However, in the light

[33] Ibid., pp. 878–879.

of the facts disclosed by recent studies, economists were ready to admit (as some of the earlier economists had done) that the transfers of workers and capital made necessary by technical changes might cause hardships to the workers, and that such hardships were serious enough to call for special action by the community and the Government.

Among the attempts to restate the "compensatory doctrine" of the relation of technical change to employment, that of Paul H. Douglas may be summarized here.[34] Douglas starts out by summarizing the facts which have aroused the fear that American workers were being crowded out of industry permanently. It is true, he says, that between 1919 and 1929, the output per man increased 45 percent, and that at the same time not only a relatively smaller proportion of the population was engaged in manufacturing, but the absolute number of workers in manufacturing fell from 9,000,000 to 8,100,000. In mining, output per person during the same period increased between 40 and 45 percent, while the number employed fell by about 7 percent. A similar trend was to be found in the railroad industry and in agriculture.

Despite these facts, Douglas holds that "permanent technological unemployment is impossible" and that improvements in machinery and in managerial efficiency will not throw workers out of employment permanently. Douglas is ready to admit that the reasons given by economists in the past (e. g., by Say) in proof of this theory are "largely inconclusive to the modern mind" because they were conceived in terms of a barter economy. He then proceeds to restate the theory in terms of our modern economy.

In substance, however, Douglas' restatement runs in terms of the same economic processes and behavior as the older theories. As technical improvements increase output per worker, they reduce the labor costs of the commodities produced. Insofar as there is full and complete competition among employers, they will vie with one another in reducing prices, and prices will fall in proportion to the reduction in costs. As prices are lowered there will be a larger demand for practically all commodities, there will be need for more workers to produce the increased quantity of goods demanded, and thus the displaced workers will be reemployed.

The important factor in the process to which Douglas gives particular emphasis is the varying elasticity of demand for different commodities. Whether the elasticity of demand of a commodity is equal to, greater than, or less than unity will determine the degree to which the price will be reduced, the extent to which market demand and production in the same industry will expand, the number of workers that may be employed in the same industry or may have to seek employment elsewhere.

> It has been just this elasticity of demand—

he writes—

> which has caused the number of persons employed in the automobile industry to increase, despite the increase in output per worker. * * * An increase in production lowered both costs and prices, but the increase in the quantity demanded more than made up for the increase in the average output, so that the

[34] See Paul H. Douglas and A. Director, "The Problem of Unemployment," New York, 1931, pp. 121–158; also Paul H. Douglas, "Technological Unemployment," American Federationist, vol. 37, no. 8, Aug. 1930, pp. 923–950.

relative number of persons employed in manufacturing increased with every decade.[35]

If the demand for a specific commodity is inelastic, an increase in output in that industry will not be accompanied by a proportionate increase in demand. In such cases fewer workers will be needed in that industry, and there may be an appreciable displacement of labor. But the displaced workers will find employment in other industries. The process is simple: The improvements in the industry necessarily lower the price of the commodity produced by that industry. As a result of lower prices, consumers are able to obtain the same quantity of goods for less money. They thus save purchasing power which they can now spend either on other necessities or luxuries or can invest in new capital goods. Thus at the same time that men are being squeezed out of one industry purchasing power formerly expended on the products of that industry is transferred to other industries and builds up new opportunities for work. Furthermore, there is an exact mathematical relationship in the process.

Not only are new opportunities for employment built up * * * but they are built up to an equal degree to that by which the older opportunities decay. For every man laid off a new job has been created somewhere, and the ratio between monetary purchases and employment is still the same as before.[36]

Such a transfer of workers from some lines of employment to others took place between 1919 and 1929 when—

young men who otherwise would have been farmers or clothing workers have in fact become movie ushers, saxophone players, and house-to-house canvassers.

Differences in elasticity of demand thus determine whether there will be shifts to new industries, and to what extent. The gist of this reasoning is summed up as follows:

Improvements in industrial processes, like changes in demand, will produce, therefore, a shifting of labor and capital within the economy as workers and investors transfer themselves from industries where their return in terms of exchange value is less than the average to industries where the return is above or approaching the average. These shifts are inevitable in a progressive society where there is a tendency toward an equalization of return. Those thrown out of work will not, however, be permanently unemployed, and to this degree, therefore, the fears of permanent technological unemployment have been greatly exaggerated.[37]

The process and ultimate results are the same when an increase in output is obtained not by mechanical changes but by improvements in managerial methods. Whether employers eliminate waste through more scientific methods or shut down inefficient plants or regularize production, in all cases the displaced workers will be reabsorbed owing to the fact that the savings of consumers, owing to lower prices or the increased earnings of the workers retained, will increase production and purchasing power.

The general thesis that "permanent technological unemployment" cannot occur is not invalidated by the fact that owing to the existence of interest and rental payments the reduction in total costs may not be as great as the reduction in labor costs. Neither is it affected by the existence of restrictions on competition such as price agreements and other monopolistic practices. The only difference is that under

[35] *American Federationist*, Vol. 37, No. 8, Aug. 1930, pp. 927–928.
[36] Ibid., p. 930.
[37] Ibid., pp. 930–931.

conditions of monopoly the gains from the technical improvements are appropriated in larger measure by employers in the form of larger profits. But the employers must either spend their added gains for luxuries or invest them. In either case, they increase the demand for commodities and draw the displaced workers into other industries. The general argument may be summed up in Mr. Douglas' own words, as follows:

Summing up, therefore, we can say that the displacement of workers from their former occupations because of technological changes will be greater: (1) The less the quantity demanded of a commodity increases with a given reduction in price per unit; (2) the less is the proportion which labor costs form of the total expenditures; (3) the less is the degree to which a reduction in costs will reduce price; and (4) the less important is the operation to the whole industry.

In other words, therefore, the amount of displacement from former to other jobs will vary inversely with the elasticity of demand, the importance of labor in the final product, the degree of competition, and the relative importance of the operation or operations primarily affected by the technical changes.

In any event, however, employment opportunities are being built up elsewhere which will ultimately be adequate to provide for an added number of workers equal to those who under such conditions may have been eliminated from any given industry.

In the long run, therefore, the improved machinery and greater efficiency of management do not throw workers permanently out of employment nor create permanent technological unemployment. Instead, they raise the national income and enable the level of earnings and of individual incomes to rise.[38]

While technical improvements, according to this theory, do not create any long-run problem of unemployment, they necessitate readjustments which take time and which may cause temporary unemployment. Even when owing to an increase in demand for the product workers are reemployed in the same industry, it takes some time before the "pick-up" in demand makes itself felt in such a way as to induce manufacturers to expand production, and in the meantime many workers are laid off. When workers have to shift from contracting to expanding industries, there is also a time lag, for the contraction takes place more quickly than the expansion and expanding firms may work longer hours with the same number of workers before entering on a program of larger production. The change-over in occupations is further complicated by the fact that workers are reluctant to change their trade or place of residence and that they may be hampered in their movements either by strong local ties such as home ownership or by lack of funds to pay the expenses of moving to a new place. Finally, even if workers are transferred to new jobs, they often have to take jobs which are less satisfactory to them and which pay lower wages. "From all of these causes, therefore," says Douglas, "technological and business change creates a considerable amount of temporary unemployment which in the short run creates havoc."[39]

Douglas suggests a number of remedies to alleviate such hardships. He lays particular stress on "the forecasting by competent organizations of the industries and trades in which displacement of labor is most likely to occur and the probable degree of displacement which may be expected." By predicting more or less accurately impending technical changes and the elasticities of demand of the commodities,

[38] Ibid., p. 938.
[39] Ibid., p. 942.

it would be possible to adjust the labor supply to the production needs of different industries. Unemployment would also be reduced by better timing, namely, by introducing technical improvements during periods of prosperity; by better organization of the labor market through public employment offices; by "revamping" our system of vocational training. The hardship caused by temporary unemployment could be alleviated by means of a dismissal wage for those forced out of an industry and by an adequate system of unemployment insurance.

The same position was formulated in more concrete terms by Wilfred I. King.[40] In brief, King agrees that the displacement of men by machines has been going on rapidly for two centuries. Though most of the men displaced find new work "rather promptly," there are many instances in which skilled workers are compelled to accept unskilled work at lower wages. Also many older men may never regain their status, and even in the best of times, some displaced workers will be idle for days or weeks. "It is clear, therefore, that there is such a thing as technological unemployment." But it is "negligible" in volume, and it does not in the least invalidate the contention of the "orthodox economists" with regard to the long-run effects of technical progress.

The present situation—

writes King—

may be summed up by saying that no facts or figures thus far discovered cast any doubt upon the approximate validity of the orthodox economic theory that the forces giving rise to technological unemployment tend, at the same time, to create a demand for new goods, and that the production of these new goods normally calls for a volume of labor roughly equaling the quantity displaced. From this premise it follows that since labor-saving devices increase production without materially decreasing the ability of workers to find jobs, such devices are decidedly beneficial rather than injurious to society as a whole.[41]

King further claims that labor tends to obtain a liberal proportion of the gains in national income due to technological improvements.

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[40] W. I. King, "The Relative Volume of Technological Unemployment," Proceedings of American Statistical Assn., 1933.
[41] King, loc. cit.

CHAPTER III

RECENT STUDIES AND REPORTS, 1934–40

GENERAL CHARACTER OF RECENT STUDIES

The course of economic events in the United States after 1933 did not allay the debate on technological unemployment. On the contrary. The persistence of a large body of unemployed even during the peak of recovery in 1937, the continued lag in the indexes of employment as compared with indexes of production in mining, manufacturing, and other industries, the apparent difficulties of placing new entrants in industry and other unfavorable aspects of the employment situation, gave the issue greater urgency. The question of the effects of the machine on the worker's condition, and especially on his opportunities of employment, remained in the forefront of public discussion.

Opinion in the United States during these years, as in the preceding periods, continued to be divided. On the one extreme were those who hailed the machine as the agency of social-economic advance and as the creator of jobs and who refused to admit that there can be such a thing as "technological unemployment." This view was defended by employers and engineers, and by a considerable number of economists. In a letter addressed to the chairman of a sub-committee of the Committee on Labor of the House of Representatives which held hearings on the subjects in February and March 1936, Noel Sargent, secretary of the National Association of Manufacturers, wrote:

> In a special study, the National Industrial Conference Board, presented a partial list of the new industries which have made extensive use of labor-saving devices, but which in turn have created new fields of direct and indirect employment for those who had lost their positions in the particular obsolete fields.
>
> These industries are—
>
> Electrical machinery, apparatus, and supplies.
> Motor vehicles.
> Auto parts and bodies.
> Rubber tires and inner tubes.
> Manufacture of gasoline.
> Rayon and allied products.
> Manufactured ice.
> Aluminum manufactures.
> Typewriters and parts.
> Mechanical refrigerators.
> Cash registers and adding and computing machines.
> Oil, cake, meal, cotton seed manufacture.
> Aircraft and parts.
> Phonographs.
> Photographic apparatus and materials.
> Motion-picture apparatus.
> Asbestos products.
> Fountain pens.
>
> When these new industries became a part of our business structure they, without a doubt displaced workers in obsolete fields and workers on obsolete machinery at the time of such introduction. However, the new labor-saving devices brought

in their wake bigger industries, need for more raw materials, more wholesale and retail merchants, and greater transportation facilities.

The final results of the study mentioned above showed that because of the development brought about by these new labor-saving devices and new technological developments the average number of wage earners per 100,000 of total population in all manufacturing industries increased from 4.944 in 1879 to 7.273 in 1929. This represented more than a 45 percent increase in the number of manufacturing wage earners per 100,000 population. These figures do not, of course, include the vast increase in employment opportunities which developed at the same time in the distribution and servicing of these new and improved products.[1]

At the other extreme were those who continued to blame technical progress for the large amount of unemployment in the United States. Among the documents placed before the sub-committee referred to above was a letter from the president and secretary of the National Organization for Taxation of Labor-Displacing Devices which read in part as follows:

> The economists of big business, and their journalistic hirelings have made a fetish of machine progress. They develop more labor-displacing devices, cut down pay-rolls, and try to squeeze dividends out of a surfeited market. This gigantic conspiracy against American labor has brought our total unemployed to over 11,000,000 people, and still they call it "progress."

And further—

> The use of mechanical power is the main factor in the increase of production, and decrease in employment opportunities. Therefore, labor-displacing devices must be recognized as the principal cause of the existing unemployment situation.[2]

Similar views were expressed by representatives of organized labor, both in the A. F. of L. and in the C. I. O.

Between these extremes were the advocates of a middle position, to the effect, namely, that there was no problem of technological unemployment "in the long run," but that it was definitely a problem "in the short run." Opinions differed as to how serious the problem was, its exact nature, and how it should be dealt with.

Considerable advance, however, was made during these years in preparing a factual and theoretical basis for a clearer analysis of the problem. The work done between 1934 and 1940 has thrown a great deal of light on various aspects of the problem—on methods and measurements of mechanization, on the effects of industrial improvements upon skill and efficiency, on the relation of such improvements to output, on the interrelations of technical progress to general economic processes, etc. While this work of research and analysis has left room for disagreement on the main question, it has undoubtedly narrowed the area of disagreement. It has developed more fully concepts and methods which are necessary for a more effective approach to the problem, both theoretically and practically. It has helped to place the problem in better historical perspective by bringing within the view of current thinking some of the antecedent discussions of the subject. And it has brought to light a large amount of descriptive and statistical data as a basis for re-evaluating the nature of the problem and the validity of the proposals made for its practical solution.

The work done during these years in this field of inquiry is voluminous, and only a small part of it can be considered here. The studies

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[1] Investigation of Unemployment Caused by Labor-Saving Devices in Industry. Hearings before a sub-committee of the Committee on Labor, House of Representatives, 74th Cong., 2d sess. on H. Res. 49; Washington, 1936; p. 87.

[2] Ibid., pp. 79–82.

selected for examination deal with the problems of mechanization, labor displacement, industrial growth, and capital formation. Some of these studies were sponsored by Government or private research institutions, while others were carried out by economic writers individually.

MECHANIZATION AND LABOR DISPLACEMENT

In 1934 the National Bureau of Economic Research published a study on Mechanization in Industry analyzing the results of a survey conducted over a period of years by Dr. Harry Jerome. In this study, Dr. Jerome set himself the task of giving a systematic account of the process of mechanization, and of providing methods for measuring its extent and some of its industrial consequences.

The scope of Dr. Jerome's study is limited in two ways. First, while recognizing fully the great importance of non-mechanical changes in industry, such as the sub-division of labor, better use of equipment, standardization and simplification of products, improvements in the quality of raw materials, elimination of seasonal fluctuations, budget control, market forecasting, methods of selecting workers and determining wages, shipping methods, etc., Dr. Jerome is concerned only with mechanical changes in the strict sense of the term. His use of the term is described as follows:

> In the broadest sense we mean by mechanization the use of tools or equipment of any kind to aid the human brain and muscle, and by "increasing mechanization" we refer to any change in methods or equipment that tends to lessen reliance on the unaided mental and manual endowment of the worker * * *. Our interest centers chiefly, however, in power mechanization—in the increasing reliance on equipment driven by generated power, be it steam, electricity, compressed air, or gasoline that furnishes the motive power.[3]

Second, the study deals entirely with labor-saving mechanical changes—their forms, causes, and growth. Dr. Jerome draws a distinction between "productivity-increasing" changes (those which increase the units of output per hour of labor) and "labor-displacing" changes (those which reduce the number of workers required). While recognizing the close relation of the two concepts, Dr. Jerome centers his study on the latter. The effects of labor-saving devices on employment, skill, industrial health, etc., are considered briefly, with more emphasis on labor displacement than on other effects.

The process of mechanization is made considerably clearer by considering it in relation to specific operations and by breaking down labor-saving mechanical changes into a number of types. Dr. Jerome points out

> four fairly obvious ways in which changes in equipment may reduce the labor requirement, relative to the output, on specific operations, namely, by: (1) eliminating one or more hand operations; (2) increasing the speed of the machine; (3) enlarging capacity (through greater physical size) without corresponding increases in the labor requirements for feeding and attention; (4) substituting a different process requiring less labor, such as the substitution of electric welding for riveting.
>
> The use of better materials or a greater durability of machine parts has, by keeping the machine in steadier operation, substantially the same effect as making the machine faster or larger.[4]

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[3] Harry Jerome, Mechanization in Industry, National Bureau of Economic Research, New York, 1934, p. 41.

[4] Ibid., p. 42.

A detailed historical account is presented in Dr. Jerome's study of recent changes in technique and equipment in American industries—agriculture, manufacturing, mining, construction, transportation, service industries, and in the handling of materials—and a comprehensive picture of the use of mechanical appliances at the time of writing is presented. It is the most comprehensive statement on the subject that had hitherto been made. In describing the mechanical changes in specific industries, attention is given to their effects on productivity as measured by annual output per man or by output per man-hour, on the particular ways in which skills were leveled, processes and occupations modified or combined, and the number of workers required affected. Particularly illuminating are the results of the special surveys in particular plants, showing the number and character of new installations, methods and processes and their effects on labor used before and after the changes in equipment and methods of production.[5]

While the descriptive portions of Dr. Jerome's study are interesting, of much greater importance are the various methods he suggests for measuring "changes in mechanization" in time, and for comparing "the degree of mechanization" between industries at the same time. While the same methods are applicable for both purposes—

some modes of measurement may be more serviceable for the comparison of differences in mechanization at a given date while others are more available or more useful for the comparative study of the process of mechanization over a period of time.[6]

The use of the various methods depends upon the availability of the necessary statistical data for different industries and periods of time, on the scope and limitations of these data, on their comparability, and on the degree to which their value is affected by complicating economic processes. Dr. Jerome examines the data available for the use of different methods and points out their validity as well as their defects for the purpose.

On the basis of the nature of the process of mechanization and of the data at hand, Dr. Jerome distinguishes five general methods for measuring mechanization, which are given in appendix A. He classifies the factors which determine the rapidity of mechanization under three headings: "Technological," "Pecuniary," and "Psychological." These are not entirely independent or mutually exclusive. Dr. Jerome thinks that "It is scarcely too much to say that a machine can be manufactured to special order to perform almost any series of operations when the need becomes sufficient to justify the expense."[7] Still, mechanization is retarded by the "limited selective ability of the machine" and by local and temporary technical difficulties due to plant construction and other conditions. The use and spread of mechanical devices are also limited by considerations of costs and profitability. Technical progress generally outruns the actual advance of mechanization owing to the fact that a fuller use of machinery may involve an increase in overhead costs or discarding existing plant which employers are reluctant to scrap, or it may call for financing which the management finds it difficult to arrange, etc.

[5] Ibid., chapters III–V
[6] Ibid., p. 255.
[7] Jerome, op. cit., p. 329.

Among the factors which stimulate mechanization may be mentioned the ability of vertical combinations to finance new inventions, a large volume of funds at low interest rates (as existed in the United States between 1922 and 1929), large-scale production,[8] an extensive market, and standardized production and consumption. Considerations which tend to retard mechanization are irregularity of production, short operating seasons, and the availability of casual labor, a shorter working day, frequent style changes in the industry, small-scale production, diversity of procedures, and the stagnant or declining state of the industry.

The rate of mechanization is also affected by the level of wage rates relative to other costs and by the marketing policies of the machine producing firms. In general, "Other things being equal, high wages encourage the use of machines and stimulate efforts to perfect them, while cheap labor retards mechanization."[9] However, where wages are very low, labor may not be sufficiently cheap to prevent the introduction of some mechanical equipment. The trend toward mechanization is accentuated by a rising wage level. It is also hastened by shifts in the relative wages of different grades of labor, especially by a rise in the wages of unskilled relatively to those of skilled workers. But the effects of wages are often overshadowed by other factors, Mechanization in the United States between 1922 and 1929 was very rapid, though the differential between the wages of unskilled and skilled workers tended to widen owing to a fall in the wage rates of the unskilled.[10] The marketing policies of machine producers and the degree of competition in machine using industries may promote or retard mechanization, according to circumstances.

Among the psychological factors the attitudes of employers and of organized labor are of special importance. Employers may be influenced by inertia, uncertainty as to the value of a new device, failure to recognize its merits, or concern for their workers. The attitude of labor toward machines is determined largely by the expected effects on jobs, skill differentials, and earnings. The position taken by labor toward the introduction of the machine has "varied over a wide range, from vigorous attempts to prevent its adoption and use, through discouraged indifference to its progress or acceptance qualified by restrictive control measures, to reluctant acquiescence, and finally, to the stage of cooperation for efficiency where the worker not only acquiesces in but even helps to initiate innovations, with the hope of sharing in the resulting gains."[11] As a rule, a refusal on the part of unions to permit their members to operate machines has rarely been effective for any length of time. The workers have been more successful in prescribing the conditions under which new machines may be used.

In considering the effects of mechanization on the quantity of labor required, Dr. Jerome advances the discussion of the subject by a closer analysis of terms and by suggesting methods for measur-

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[8] "The relatively large initial expense of mechanized equipment, and the facts that in small plants there may not be sufficient work to keep a machine busy and that machines cannot ordinarily be transferred from one type of work to another without adjustments and additional expense, make high mechanization dependent in considerable part upon mass production. Hand methods survive chiefly where variety and distinction, quality and individuality are the primary considerations." (Ibid., p. 338.)

[9] Ibid., p. 344.

[10] Ibid., pp. 345–348.

[11] Ibid., p. 356.

ing labor displacement. In the first place, he distinguishes clearly the various elements of labor affected by mechanization. Dr. Jerome says:

In computing the effects of productivity-increasing improvements, it is essential to note what labor is included. For this purpose we may distinguish operating, auxiliary, embodied, and indirectly required labor. Operating labor is that required directly in a particular process, such as the operation of a brick-molding machine. Auxiliary labor is that required in the plant for such operations as oiling, inspecting, adjusting, and repairing the machine—in short, all plant labor that is necessitated by the use of the machine but is not considered as engaged in its direct operation. Embodied labor is the labor applied to the production of the machine itself and the materials of which it is made (prorated over the useful life of the machine), to the production of the materials used in machine repairs, and to the production of the power, oil, grease, and other materials, if any, consumed in the operation of the machine. Lastly, we may extend the scope of our comparison still further by seeking to include not only the labor required in the factory production of the given commodity and in the production of the equipment used in the factory, but also the additional labor required to put the given commodity in the hands of the final consumer ready for use * * *. It is the labor required beyond the manufacturing stage that we have designated as "indirectly required." While studies in productivity and labor displacement ordinarily stop short of the point of allowing for all these indirect factors, we should recognize that until they are included we have not ascertained the real change in productivity or the real amount of labor saved or displaced.[12]

The term "labor displacement" is also given a more precise meaning. "Labor displacement is a decrease in the number of workers required in (1) a specified operation * * *; (2) the plant as a whole; (3) an occupation, such as carpentry, wherever practiced; (4) an industry as a whole."[13] In accordance with these changes, we may have (1) operation labor displacement; (2) plant labor displacement; (3) occupational displacement; (4) industrial displacement; or (5) complete displacement. Summarizing his analysis, Dr. Jerome writes:

* * * labor saving sometimes means an increase in productivity, sometimes a displacement of labor; the two concepts are not necessarily identical. Furthermore, the productivity comparison may be based upon only the direct operating labor or may be broadened to include auxiliary, embodied, and indirectly required labor. In like manner, discussions of labor displacement may refer only to the effect on the size of the crew in a given operation, on the labor in the plant as a whole, on the number in a given occupation, in a given industry, or in employment of any kind. Finally, there may be displacement of one type of labor, balanced more or less by increase in another type; there may be displacement of skill as well as of number * * *

In practice most discussion of labor saving refers to labor displacement or increasing productivity in specific operations or plants, sometimes with and sometimes without allowance for increase in output, but ordinarily not allowing for all of the offsetting increases in embodied and indirectly required labor.[14]

The above distinctions lead to the following definition: Technological unemployment is the complete displacement of workers from all industry either temporary or permanent, which arises from a technological change.[15] Technological unemployment may occur, even when the total demand for labor is unchanged, as a result of occupational and industrial changes. Even when operation and plant labor displacement is offset by increases in the employment of

[12] Ibid., pp. 28–29.
[13] Ibid., p. 30.
[14] Ibid., pp. 31-32.
[15] Ibid., p. 31.

indirect labor, "we have no assurance that the additional men" employed in producing machinery or in transporting the product will be "the same men replaced in the plant or even men of the same occupation or skill. There may be occupational and industrial labor displacement with possibly some technological unemployment, even though the total demand for labor in the industry is unchanged. There may be numerous shifts that result in increasing employment for some individuals and types, and decreasing employment for others."[16]

In measuring labor displacement, it is desirable to distinguish between (1) actual displacement, i. e., the number of workers known to have lost work on an operation or in a plant, etc., regardless of change in output; (2) constructive displacement, which expresses the ratio between the labor required under the new method and the labor which would be required under the old method to produce the same total output. This difference is "constructive displacement" for ordinarily we cannot assume that the total output would have been the same if the old methods had been retained; and (3) potential labor displacement which is an estimate of the total labor displacement which might reasonably be expected to occur upon general adoption of a new machine; such an estimate implies information on the number of persons in the occupation affected, on the labor reduction ratio attributable to the machine, and the percentage of plants in which the use of the machine is feasible.

Dr. Jerome presents a number of examples showing the effects of selected technical changes on the quantity of labor required. He emphasizes the fact that a substantial part of the total reduction of labor requirements in an industry takes place by a gradual process of nibbling away at the size of the staff required. But he is more concerned with the possibilities of estimating aggregate constructive displacement in industry for which he suggests four methods:

"Method A, the fixed-base, current year output method, answers the question: How much less labor did it require to produce the current output than would be required at the productivity rate of the base year?"[17] The algebraic formula of this method is

$$T=P_1\ (L_1-L_0)^{18}$$

Method B, the fixed-base, base-year-output method, answers the question: How much less labor would be required to produce the base-year-output at the current productivity rate than actually was required at the base-year productivity rate?"[19] The algebraic formula for this method is:

$$T=P_0\ (L_1-L_0)$$

Method C, the year-to-year, current-year-output method, answers the question: What is the cumulative constructive displacement when the displacement for each year is computed by multiplying the current-year-output by the differential between the labor requirement ratios of the current and the immediately preceding year?"[20] The formula for Method C is:

$$T=\Sigma[P_1\ (L_1-L_0)]$$

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[16] Ibid., pp. 34–35.
[17] Ibid., p. 377.
[18] "T = the constructive technological change in the volume of employment (expressed in number of workers or man-years, man-weeks, man-days, or man-hours) * * *.
P_1 = total output in physical units in the current year; P_0 in the base year.
L_1 = the labor requirement ratio in the current year (labor per unit of output); L_0 in the base year." (Ibid., p. 376.)
[19] Ibid., p. 377.
[20] Ibid., pp. 377–378.

Method D, the year-to-year, preceding-year-output method, answers the question: What is the cumulative constructive displacement when the displacement for each year is computed by multiplying the output of the preceding year by the differential between the labor requirement ratios of the current and the immediately preceding year?"[21] The formula for Method D is:

$$T = \Sigma[P_0 (L_1 - L_0)]$$

Dr. Jerome gives—

a simple hypothetical example * * * to make clearer the differences in these four methods. Assume that in 1927 an industry employing on the average 100 workers had an output of 1,000 units and hence a labor requirement ratio of 0.1 worker per unit. The corresponding data for 1928 are 100 workers, 2,000 units of output, and a labor-requirement ratio of 0.05 workers per unit; and for 1929, 150 workers, 6,000 units of output and a labor-requirement ratio of 0.025 workers per unit.

Under the conditions assumed, the constructive labor displacement in 1929 is 450 if the differential in 1927 and 1929 in the labor-requirement ratios is applied to the 1929 output (Method A), but only 75 if it is applied to the 1927 output (Method B). But if the year-to-year method is applied by first estimating the displacement from 1927 to 1928, and then from 1928 to 1929, and cumulating the two results, the displacement is 250 if the labor-requirement differential is applied to the current year output in each instance (Method C), but only 100 if it is applied to the preceding year output (Method D).[22]

The year to year method is regarded by Dr. Jerome as nearer to reality than comparisons with a distant base.

In the first place, the year-to-year changes in employment due to technological improvements are probably more important than the relatively long-time or possibly permanent displacement effects. Furthermore, the significance of estimates of the constructive displacement of labor is obscured by any degree of interdependence between changes in total output and in productivity rates. If total output and productivity are independent of each other over a long period, then the fixed-base method may be reasonably accurate; but if, as is more often true, the trend in the total output of the industry is in part both effect and cause of changes in the rate of productivity, then of the two methods, the comparisons with the preceding year as a base are the less likely to be distorted by the interdependence of changes in total output and in productivity rates.[23]

Estimates of constructive labor displacement have serious limitations. They tell us nothing about the factors responsible for changes in productivity, they do not indicate whether the identical workers who were made unnecessary by gains in efficiency are those who have been absorbed by increases in output. Nor do they explain to what extent changes in employment have absorbed the increases in population of working age, or suggest the rate at which occupational readjustment takes place. In view of the general "crudity" of our industrial mechanism, Dr. Jerome concludes that at least some temporary technological unemployment must occur and that the tendency is "for technological changes to result in a substantial period of unemployment for the men displaced and frequently to necessitate their taking employment at a lowered wage."[24] He does not find convincing evidence, however, of an inherent tendency for mechanization to create an ever larger permanent body of unemployed. "The element of truth in this charge against the machine lies in the fact that there is a lag in absorption; and consequently the more rapid the displacement, the greater, probably, is the pool of at least temporarily unemployed work-

[21] Ibid., p. 378.
[22] Idem.
[23] Ibid., p. 379.
[24] Jerome, op. cit., p. 387.

ers. It may be a pool made up of ever changing individuals but even at that it represents in a sense a more or less permanent addition to the volume of unemployment."[25]

PRODUCTIVITY, PRICES, AND EMPLOYMENT

Among the studies sponsored by the National Bureau of Economic Research which have dealt with the more general economic aspects of technical change are those by Frederick C. Mills. Three of these are of special interest, namely, Economic Tendencies in the United States published in 1932; Prices in Recession and Recovery which appeared in 1936, and Bulletin 70 of the Bureau entitled "Employment Opportunities in Manufacturing Industries of the United States," dated September 25, 1938. In these three studies, Dr. Mills has developed the thesis that technical changes result in industrial displacement, has supplied an estimate of the decline in employment in recent years which may be attributed to technological factors, and has discussed the connection of such unemployment with the incidence of the gains from increased productivity and with the general operation of the price system It may be convenient to consider the results of each of these studies in the order in which they were made.[27]

In his Economic Tendencies in the United States, Dr. Mills was concerned with changes in productivity as one of the tendencies of American economic development, and treated the problem of intraindustrial displacement only incidentally. But his treatment of the subject assumes a larger interest when viewed in relation to general economic tendencies. In the pre-war period, from 1901 to 1913, according to his computations—

> the output of manufactured goods in the United States advanced at a rate of approximately 3.9 percent a year; the volume of raw materials produced increased at an average rate of 2.2 percent a year. The increasing proportion of fabricated goods consumed with rising living standards, the steady advance in fabrication outside the home and changes in the character of our foreign trade help to account for these differences.[28]

Significant also was the unevenness in the rates of growth of different industries and of groups of industries

> The output of articles of human consumption increased between 1901 and 1913 at a rate of 2.6 percent a year, a rate comfortably in excess of the rate of growth of population (2.0 percent a year). The margin of approximately 0.6 percent a year represents the increase in volume of consumption goods available per capita of the population, for raising the standard of living * * * The growth of production of this type was relatively stable. * * *
>
> The output of additions to the total supply of capital equipment increased by 5.0 percent a year. * * * Per capita of the population, the annual increments to the country's stock of capital equipment (including replacements) were increasing at a rate close to 3.0 percent a year. Current well-being * * * was being steadily enhanced during this period. More rapid, however, was the flow of new goods (and replacements) into the fund of capital.[29]

The growth in the physical volume of manufacturing industries in the 15 years between 1899 and 1914 was due, in the first place, to

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[25] Ibid., p. 388.

[27] Since the above was written, there has appeared Bulletin 80 of the National Bureau of Economic Research, September 9, 1940, which contains a study by Frederick C. Mills on The Anatomy of Prices, 1890–1940, which also bears on the subject.

[28] Frederick C. Mills, Economic Tendencies in the United States, National Bureau of Economic Research, New York, 1932, p. 12.

[29] Ibid., pp. 21–22.

an increase of 36.1 percent in the number of wage earners (averaging 2.2 percent a year). In the second place, it was the result of advancing productivity (averaging 1.7 percent a year). Dr. Mills uses the term productivity as equivalent to output per wage earner per year, and his index is based on the number of wage earners in manufacturing plants; no account is taken of salaried workers or of changes in hours of work. Furthermore, no attempt is made to explain the factors (human, mechanical, organizational) which made for higher output. Dr. Mills says:

It is to be borne in mind that index numbers of per capita output do not measure changes in the specific productivity of labor. Per capita productivity may increase because of improvements in equipment or in industrial organization, increased skill on the part of personnel or enhanced productive capacity due to changes in any of the factors of production. Indexes of per capita productivity may be accepted as measures of changes in the productive efficiency of industrial organizations viewed as functioning units, but not as measures of the net contribution of any one factor to these changes.[30]

The relative increases in number of workers and in output per worker were uneven when considered by 5-year periods. This is shown in the foll wing table:[31]

Census interval	Increase in volume of manufacturing production (percent)	Increase in number of wage earners (percent)	Increase in output per capita (percent)
1899-1904	+20.2	+8.1	+11.2
1904-9	+28.5	+20.2	+6.9
1909-14	+14.1	+4.7	+9.0

Commenting on these tendencies, Dr. Mills writes:

The record of the 15 years from 1899 to 1914 indicates that the factors responsible for the great advance in production of manufactured goods were an increasing number of workers, larger and better equipped establishments, and steadily rising output per worker employed. (The growth of demand was, of course, essential to the realization of the advantages of large-scale production.) The stream of manufactured goods produced in 1914, a stream greater by 76 percent in volume than that of 1899, was turned out by a working force (of wage-earners) only 36 percent greater, and by a number of establishments only 13 percent greater. There are clear signs here of the growing emphasis upon technical efficiency and enhanced productivity per unit as factors of increased production, an emphasis which has been even more pronounced in recent years.[32]

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[30] Ibid., p. 28, footnote 1. The limitations in measuring productivity are stated by Dr. Mills as follows in The Anatomy of Prices, 1890–1940, p. 8, footnote 12:

"The term productivity is perhaps open to misinterpretation. For purposes of comparison it is useful to express changes in the aggregate output of manufacturing industries in ratio to changes in certain standard quantities. Thus the standard of reference might be number of manufacturing establishments, horsepower used in production, number of dollars invested in capital equipment, number of men employed, or man-hours worked. Such ratios may be thought of as measures of productivity. However, we should not assume that exclusive responsibility for observed changes in aggregate output attaches to the factor represented by any particular standard of reference. Changes in production are resultants of the interplay of organizational, managerial, equipment, and labor factors, operating jointly in the productive unit.

"Even for a single establishment the productivity measurement is an average, reflecting the combined resultant of the application of diverse skills, utilizing various tools, to widely different types of materials. In default of detailed information about the effectiveness of effort applied to specific tasks under controlled conditions, such an average has its value, but it suffers from all the defects of averages in general. This limitation is more marked, of course, when the average is for an entire industry, or for the heterogeneous activities that constitute manufacturing enterprise as a whole. Such an average provides but a crude measure of the play of the thousands of specific factors that affect the fruitfulness of productive effort in fabricational processes."

[31] Mills, Economic Tendencies in the United States, p. 28.

[32] Ibid., pp. 38–39.

Dr. Mills relates the changes in production with the price movements which were taking place during the same period. In the general trend of rising prices there was a persistent divergence of prices in different sectors of the economy. The "real worth" (real purchasing power) of raw materials was advancing while that of manufactured goods was declining.

Among raw materials the gains in real worth, per unit of product, were greatest for farm crops; the purchasing power of these commodities increased at the notable rate of 1.5 percent a year. * * * Producers of raw minerals suffered a decline in purchasing power per unit of product. * * * Producers' goods [in general were] cheapened slightly, [while] consumers' goods [gained] slightly in real value. This was due to the fact that (leaving out the influence of monetary factors) the prices of producers' goods were affected by the lower prices of fabricated mineral products, by falling production costs and widening markets. On the other hand, consumers' goods showed an upward tendency owing to the rising values of farm products, especially of food-stuffs. The divergence between these two classes of goods, however, was not very marked.

The divergent price trends of the pre-war period meant a divergence in the fortunes of the different groups of the population. American farmers experienced a rise in their scale of material well-being. On the other hand, the increased industrial productivity did not result in any substantial addition to the real income of employed workers in general, while the real returns of manufacturing labor actually declined (at the rate of 0.1 percent a year).[33] These shifts in the terms of exchange between farm and non-farm elements of the population and the inequalities in the gains from increasing productivity are accounted for by differences in productive conditions such as the slower rate of increase in the output of farm products, the varying effects of monetary conditions, and the repercussions of improved techniques and widening markets particularly upon costs and prices in the manufacturing industries.

Following the same method and using a large array of statistical data, Dr. Mills traces in similar fashion the economic tendencies of the period from 1922 to 1929. The aggregate output of movable goods (i. e., excluding construction) increased 34 percent during this period; both aggregate and per capita output were higher than in the pre-war era, as shown below:[34]

Year	Average annual rate of increase in—		
	Volume of production (percent)	Population (percent)	Production per capita of population (percent)
1901–13	+3.1	+2.0	+1.1
1922–29	+3.8	+1.4	+2.4

There was a wide margain during this period (1922–29) between the rates of growth of raw materials and manufactured goods, farm and non-farm products. The output of raw materials increased at an average annual rate of 2.5 percent; manufactured goods at a rate of 4.5

[33] Ibid., pp. 82–85, 133.
[34] Ibid., p. 244. "Productive services rendered directly, and not embodied in goods, are necessarily excluded. There is reason to believe that 'production' of this non-material type was growing in relative importance during this period, but the degree of advance cannot be estimated with any accuracy." (Ibid., p. 245.)

percent a year, farm products advanced at a rate of 2.0 percent a year, while non-farm products increased at a rate averaging 5.1 percent a year. Within these major groups there were wide divergences in the rates of growth of individual industries. Total construction averaged $6,700,000,000 per year (in estimated value of contracts awarded); the annual average rate of growth (in volume) was 8.1 percent for commercial buildings, 9.3 percent for industrial buildings, 4.7 percent for public and institutional buildings, 3.7 percent for apartments and hotels, 5.1 percent for one and two family houses, and 11.4 percent for public works and utilities.[35]

Great differences marked the production of different classes of consumption goods during these years. The output of foods increased at an average annual rate of 1.6 percent (barely above the rate of population growth which was 1.4 percent); other perishable consumption goods (excepting gasoline, kerosene, anthracite coal, newsprint and a few others) also lagged behind the general advance in production; so did the production of semi-durable goods (boots and shoes, textiles, etc.). It was among durable consumption goods (automobiles, furniture, electrical equipment, etc., including residential construction) that the great expansion of output took place (6.3 percent per year for durable consumption goods and 4.3 percent for residential construction). The rapid increase of consumer expenditures occurred, in the main, in the markets for goods which are more or less durable, and it was the swelling production of these goods which gave this period its characteristic tone.[36]

Even greater than the rate of growth of durable consumption goods was that of production goods or capital equipment. Finished equipment, including non-residential construction and public works, expanded at the average annual rate of 6.4 percent. Again there were wide discrepancies between the industries entering into this general division: the output of machinery advanced 7.3 percent a year, while transportation equipment declined 1.1 percent a year. But in general, an increasing proportion of our total annual output of goods took the form of equipment designed to further the processes of round-about production.[37]

Among the economic tendencies of the period from 1919 to 1929, one of the most striking features was that the advance in productivity in manufacturing industries was accompanied by a decrease in the total labor force employed. "From 1919 to 1929 output per worker employed increased approximately 43 percent among the industries" covered in Dr. Mills' sample.[38] "The work that required 100 men in 1919 could be done by 70 in 1929. Thirty out of 100 could have been dispensed with, * * * if no increase in aggregate output had been desired. Productivity per worker increased between 1919 and 1929 at an average annual rate of 3.8 percent," and between 1923–29 at a rate of 3.3 percent a year (compared with rate of increase of 1.7 percent a year between 1899 and 1914.)[39] This increase was accompanied on the one

[35] Ibid., pp. 250–264.
[36] Ibid., pp. 270–275.
[37] Ibid., pp. 277–280. Dr. Mills shares the view that the devotion of so large a proportion of the country's productive energies to the construction of capital equipment was a factor in the collapse of 1929, though "we lack a criterion * * * for determining the optimum relations between output of consumption goods and of capital equipment, relations which may conduce to equilibrium." (Ibid., p. 281.)
[38] The sample covers from 42 to 46.7 percent of total value of products reported in the Census of Manufactures for 1923, 1925, 1927, and 1929. (Ibid., p. 289.)
[39] Ibid., pp. 290–291.

hand by a tendency toward large scale production (as shown by a decrease in the number of establishments of 18 percent between 1919 and 1929 and a gain in output per establishment of 68 percent during the same period), and on the other hand by a decrease in the number of wage earners. This may be seen from the following table:[40]

Census interval	Increase in volume of manufacturing production (percent)	Change in number of wage earners (percent)	Increase in output per wage earner (percent)	Change in number of establishments (percent)	Increase in output per establishment (percent)
1923–25	+2.4	−4.6	+7.3	−7.0	+10.1
1925–27	+1.8	−3.3	+5.2	−4.6	+6.7
1927–29	+8.4	+0.3	+8.0	+5.7	+2.6

Thus, a new tendency makes itself felt during this period. Considering the 30 years from 1899 to 1929, Dr. Mills writes:

> We note the highly suggestive fact that not once has there been a check to the increase in per capita productivity. The rate of advance has varied greatly, but the tendency toward increasing productive efficiency has persisted, in good years and bad. In general, however, the chief factor in expanding production prior to 1923 was an enlarged body of wage-earners. This was true during the great advances from 1904 to 1909, from 1914 to 1919, from 1921 to 1923. Since 1923, however, better technical equipment, improved organization and enhanced skill on the part of the working force seem definitely to have supplanted numbers as instruments of expanding production. The persistence of this tendency must compel men to consider its implications for the future.[41]

The price movements during 1922–29 differed sharply from those of the pre-war period. The years before the war were marked by a persistent upward movement of the price level. The period from 1922 to 1929, witnessed a declining movement, world-wide in its reach, due to a variety of "complex and obscure reasons." This had various effects on different groups of the population—in general unfavorable to farmers and favorable to "agents of fabrication". The effects of this general movement were complicated by the price movement during the war and post-war boom and by the liquidation of 1920–21. Owing to war demands, the prices of raw materials had advanced greatly, but for various reasons the producers of these materials were hard hit by the collapse of 1920–21. As a result, the index number of purchasing power per unit of raw materials fell from 100 in 1913 to 83 in 1921 or 17 percent. On the other hand, manufactured goods, while not experiencing as large a rise during 1914–19 were less hit in 1921, and their index of unit purchasing power in 1921 stood at 108 as against 100 in 1913, that is showed a gain of 8 percent. In 1922, therefore, there was a wide disparity between farm and non-farm commodities, a relationship quite the reverse of the situation before 1913. Between 1922 and 1929, the prices of raw materials advanced, while the prices of manufactured goods declined. But while disparities between the wholesale prices of farm and non-farm products were thus reduced, manufactured goods continued to enjoy an advantage during these years. Also, the prices received by farmers increased between 1922 and 1929 at a lower rate than that at which

[40] Ibid., pp. 291–301.
[41] Ibid., p. 291.

prices of raw farm products advanced, and the gain in purchasing power, measured in terms of commodities actually bought by farmers was 0.6 percent per year, per unit of product.[42] At the same time, prices of foods and of consumers' goods in general advanced, while those of producers' goods declined.

The price movements of these years benefited the producers of manufactured goods and resulted in increased profits. Manufacturers were favored by low prices of raw materials, increasing productivity, and lower labor costs per unit.

Increasing output and rapidly increasing productivity—

Dr. Mills writes—

brought substantial declines in labor costs per unit of product, even with high and rising wages. Conditions in world markets for raw materials favored the buyer and gave the manufacturer the benefit of relatively low prices for such materials. In this situation labor costs, per unit of manufactured goods, and material costs, per unit, declined more rapidly than selling prices. The gap in our information has to do with the course of overhead costs. During this period capital investments in manufacturing plant and equipment were increasing at a fairly rapid rate. These investments * * * were made at relatively high prices. It is thus not impossible that overhead costs per unit of product were advancing toward the close of this period, despite a swelling volume of manufacturing production. But if such advance occurred, there is no evidence that it offset other gains sufficiently to curtail profits per unit of product. In most manufacturing industries falling general prices between 1923 and 1929 brought to the producer the gains he has been supposed to reap under conditions of advancing prices and brought, in addition, declining raw material prices. These fortunate conditions combined to maintain, and in many industries to swell, profit margins. During this period we appear to have had in the majority of manufacturing industries the curious and perhaps unprecedented condition of falling general prices and falling prices of manufactured goods, combined with an expanding margin between costs and selling prices of manufactured goods, and with manufacturing profits which increased not only in the aggregate but per unit of product as well.[43].

One of the results of the post-war price movements was the improved social-economic position of the industrial wage-earner. The real earnings per capita of labor in manufacturing industries between 1922 and 1929 increased at the rate of 1.7 percent a year (as against a decline of 0.1 percent a year during the pre-war period).[44] Instead of fighting to hold his own against a constantly rising cost of living, as he did during the pre-war period, the wage-earner substantially elevated his consumption standards and exerted an influence, as never before, on production and investments.[45]

Offsetting the gains in the ~~position~~ of the workers were the increased difficulties of adjustment which he had to face and which showed themselves in unemployment and in industrial displacements. "An increasing volume of unemployment during an era of economic expansion was, considering its magnitude, a new phenomenon in our history. Equally striking are the related statistics of industrial displacement." Dr. Mills relates these difficulties of the wage earner to the other maladjustments which made themselves felt, especially to: (1) price inflexibility due to heavy investment in overhead, price regulation, monopolistic and semimonopolistic control, trade agreements, changed distributive methods, and other influences; (2) increasing share of pro-

[42] Ibid., p. 348.
[43] Ibid., p. 397.
[44] Wage rates advanced even more sharply. Earnings of unskilled male workers increased more rapidly than those of skilled. (Ibid., pp. 478–479.)
[45] Ibid., p. 414.

ductive energies devoted to durable goods which have a higher elasticity and therefore a greater instability of production; and (3) an exceptionally large accumulation of capital funds which helped maintain an upward swing in security prices and in urban real estate values. Price inflexibility inpeded the adjustments made necessary by shifts in industry, while the growth of capital facilitated mechanical improvements and was thus a major factor in technological unemployment.[46]

Dr. Mills measures the degree of industrial displacements between manufacturing industries by computing accession and separation rates, as shown in the table below:[47]

Census period	Number of industries	Average number of wage earners	Accessions	Separations	Accession rate[1]	Separation rate[2]
1923–25	320	8,483,768	234,554	646,191	2.8	7.6
1925–27	323	8,267,736	263,539	322,833	3.2	3.9
1927–29	321	8,514,427	626,267	261,135	7.4	3.1

[1] Accessions as percentage of average number employed.
[2] Separations as percentage of average number employed.

On the basis of these computations, Dr. Mills concludes:

On the average, over each of the three biennial census periods coming between 1923 and 1929, 49 men out of every 1,000 employed were separated from given manufacturing industries. Additions to the number employed averaged 45 to every 1,000 on the pay rolls of manufacturing plants. Separations measure the burden placed upon wage-earners by industrial change. That it was a heavy burden during the prosperous period from 1923 to 1929 is indicated by these figures. Not only was the rate of separation much higher than it had been over longer pre-war periods; it was higher than the accession rate, which may be taken as an index of employment opportunities in manufacturing industries. Between 1923 and 1929 men were being turned out of manufacturing industries in greater numbers than in pre-war years, while the numbers of new men taken on were relatively much smaller. High productivity and rapidly expanding production brought instability of employment and uncertainty of income to many, during this era of business prosperity.[48]

In other writings, Dr. Mills has continued to emphasize that the economic effects of a given technical change depend upon the degree of elasticity of demand for the products involved, upon the flexibility of the price system, upon the rapidity of technical changes, and upon the way in which the gains from increased productivity are reflected in the prices of different groups of commodities.[49] He combined these ideas in a more systematic way in his book on Prices in Recession and Recovery[50] to give a general view of the interrelations of increasing productivity, prices, and employment opportunities. The central fact, according to Dr. Mills, is that an increase in productivity due to technoligical change releases productive energy,[51] but that the gains in productivity may be variously distributed. The following main distributions, with consequent effects, are possible: (a)

[46] Ibid., pp. 531–540.
[47] Ibid., p. 420.
[48] Mills, Economic Tendencies, pp. 531–532.
[49] See his introduction to Harry Jerome's "Mechanization in Industry", National Bureau of Economic Research, New York, 1934.
[50] National Bureau of Economic Research, New York, 1936.
[51] Dr. Mills, as already indicated above, measures productivity as output per worker (between 1899 and 1929) and as output per man-hour since 1929. He recognizes the defects in such measurement, but regards it as adequate for purposes of his analysis. See "Prices in Recession and Recovery," pp. 435–436

Reduction in hours of work, with higher time rates of pay; selling price unchanged; no increase in demand for goods; no change in distribution of purchasing power; no stimulus to larger production; increased leisure for all workers. (b) Reduction in number of workers employed, with higher time rates to those retained in employment, no change in selling price, no change in aggregate amounts of purchasing power of labor and other groups. Increased unemployment for some, higher per capita earnings to employed labor. Some change in direction in which purchasing power will be expended. (c) Reduction in working hours with the same or a smaller force and the same time rates of pay. No change in selling price; shift in division of aggregate purchasing power, a larger proportion of it going to agents of production other than labor. Unemployment accompanies this shift. Some modification in direction of expenditures. (d) Reduction in selling prices. Initial lowering aggregate receipts and of amount disbursed to agents of production. Possible initial unemployment. Release of buying power of consumers for purchase of more goods of the same type, or other goods (depending upon elasticities of demand for various products.) [52]

For the smooth operation of the economic system, which means also greater stability of employment, it is desirable that there should be as direct a connection as possible between the purchasing power shifted and the productive energy released. The most direct connection is established when the selling price of a commodity is reduced to the full extent made possible by the increase in productivity and when the demand for the commodity is highly elastic. In such cases a large part of the purchasing power of consumers released by the reduction in price would find an outlet through an increased demand for the commodity involved. Increased production would result, with prompt reemployment of all or part of the productive energies released by the initial increase in productive power. This is the situation envisaged by the theorists of the "theory of compensation." It presupposes "a completely frictionless economy, marked by free prices, with wages and other elements of production costs completely flexible, with labor and capital completely mobile." Under such a system, the disposition of the gains from increased productivity would be a matter of indifference, insofar as economic adjustments and continuity of employment are concerned.[53]

No such direct connection can be established today since our economy is marked by frictions of many types—by rigid prices, inflexible rates for service of many sorts, and immobility of labor and capital. As a result of such barriers to the free operation of the price system, purchasing power released in one segment of the economy may exert a negligible effect on displaced labor and idle capital in a remote section, within time limits which are of practical importance for ordinary human activities. In view of this fact, the manner in which the gains resulting from higher productivity are distributed is of utmost importance from an economic and social point of view. For whether these gains from higher productivity will remain merely potential or will result in realized benefits, that is, in larger quantities of goods and in higher standards of living, will depend upon

[52] Ibid., pp. 437–438.
[53] Ibid., pp. 439–440

their distribution in such a way as to facilitate a more direct connection between enhanced purchasing power and productive energies released by new techniques.

Under present-day conditions, the distribution of the gains from increased productivity takes place through a struggle—"a three-cornered pulling and hauling contest among primary producers, agents of fabrication and consumers." [54] A full explanation of the reasons which determine the outcome of this struggle—and, thus, also the incidence of increasing productivity—cannot be given, but among the factors which have shaped the process since 1900 are the general rise and decline in prices before and after 1929, respectively, the influence of the World War, the relative strength and weakness of the bargaining position of primary producers and fabricators after the war, the stronger bargaining position of industrial labor as a result of immigration restriction, the creation of a seller's market between 1922 and 1929 as a result of new credit devices, lending abroad, etc. The developments since 1900 are summed up as follows:

> In pre-war years primary producers and consumers stood in positions of relative advantage and reaped most of the benefits of rising productivity. The tide turned with the end of the war. Primary producers lost bargaining power; the trend of prices and special post-war circumstances contributed to strengthen the position of fabricators. Among consumers, primary producers were in a weak position. The buying power of other important consuming groups was artificially bolstered, so that competitive pressure on the demand side, toward lower prices, was greatly weakened.[55]

It is the combination of the particular incidence of changing productivity with the nature of the economic frictions impeding adjustment to change that explains whether prosperity will be broad or spotty and whether or not unemployment will persist. As already indicated, the most favorable condition for the absorption of increased productivity is the establishment of as close a connection as possible between enhanced purchasing power and released productive energy. In an economy marked by frictions such as ours, it is important that the effects of changing productivity be disseminated from as many points as possible. Such wide diffusion reduces the influence of particular frictions and facilitates a more prompt utilization of released energies. On the contrary, when the gains of higher productivity are appropriated by restricted economic groups, the connection between the larger purchasing power accruing to these groups and the released productive power becomes more remote, thus impeding the adjustments to the new technical situation.

A situation in which the gains in productivity would be disproportionately reaped by particular groups, might create a prosperity limited to special groups. In such a situation, fabricational margins would be high, prices to consumers high, rewards to primary producers low, corporate earnings high, and security prices rising, labor earnings comparatively large, and yet, in view of such distribution of productivity gains, volume of sales and production would remain low, in comparison with productive potentialities and the needs of consumers at large. Under such conditions, unemployment would persist in large volume. Furthermore, under such conditions, it is

[54] Ibid., p. 456.
[55] Idem.

conceivable that portions of the increased income of the favored groups might never become effective in stimulating the productive energies released by the gain in productivity. The persistence of technological improvements might displace workers in one section of the economy while the frictions of the economic system would impede the diffusion of the augmented purchasing power of the favored group in other sections of the economy. The result would be "a semipermanent condition of concurrent prosperity among some economic groups, unemployment and persistently low returns to other groups." [56]

This is exactly the condition which characterized the post-war economic scene in the United States. Industrial displacement and technological unemployment were in evidence before 1929, and the maladjustments became more pronounced during the depression from 1929 to 1933. While the recovery from 1933 to 1936 was fairly broad and price disparities were reduced, the gains from higher productivity (which increased during these years some 25 percent) were reaped in the main by "fairly restricted groups" (manufacturing labor and the managers and owners of manufacturing plants); and shared but slightly by primary producers and consumers. This fact combined with the growing economic frictions (inflexible prices, relatively fixed overhead charges, private control, governmental regulation, etc.) explains the partial character of the recovery since 1933, and the persistence of a large volume of unemployment.[57]

Looking ahead, Dr. Mills sees a continuance of increasing productivity and a persistence of economic frictions in the future. But he thinks that society as a whole could be made to benefit from technological change, if restrictions on the competitive forces were reduced as much as possible and if manufacturers would spread as widely as possible the gains from increased productivity through lower prices.

In Bulletin 70 of the National Bureau of Economic Research,[58] Dr. Mills presents a statistical summary of the decline in employment opportunities in manufacturing industries between 1899 and 1936 and of the proportion of this decline which is attributable to technological factors. The method is essentially the same as that used in Economic Tendencies in the United States,[59] except for minor revisions of indexes and the use of more complete data. The results of his analysis are summarized as follows:

(1) Up to 1919 there was a steady increase in the proportion of the population of the United States engaged in manufacturing industries. From 1899 to 1919, though productivity per wage earner and per man-hour increased greatly, the total number of employees in manufacturing establishments more than doubled (increasing from 5,077,000 to 10,431,000). Average normal hours decreased from 59.1 to 52.3 a week, but total employment in man-hours per week increased about 70 percent.

(2) From 1919 to 1929, despite an increase of 16 percent in the population of the United States and a notable expansion in manufacturing production, there was a drop in the total number of both wage-earners and employees as well as in total employment in man-hours per week. The total employment of wage

[56] Ibid., p. 459.
[57] Ibid., pp. 459–463.
[58] Employment Opportunities in Manufacturing Industries of the United States, September 25, 1938.
[59] See pp. ——, supra.

earners in manufacturing plants declined 5 percent. Dr. Mills finds the explanation of this change in part "in fundamental technical changes that have speeded up the process of mechanization." In less degree, he finds the explanation "in internal shifts in the structure of manufacturing—changes in the character of products turned out and the relative importance of different industries in the part played by capital equipment in manufacturing operations." The technical changes may be measured roughly by over-all changes in industrial productivity.

(3) There is no simple inverse relationship between changes in productivity and in employment. Comparing the several groups of industries classified on various bases, e. g., those producing goods for human consumption, those producing capital goods, construction materials, food and non-foods, durable, semi-durable, etc., Dr. Mills finds that between 1914 and 1929 the greatest increase in the number of wage earners employed was shown by industries producing capital equipment in which at the same time volume of production and estimated output per worker increased most rapidly. In other words, there was a concurrent gain in productivity, total output, and employment which was facilitated by favorable market conditions and other factors.

(4) It was "roughly true" that between 1923 and 1929, expansions in output served to offset advancing productivity. The problems of readjustment during these years was thus largely a question of the "inter-industrial transference of labor, within manufacturing as a whole," and "the allocation to non-manufacturing industries of the man-power coming on the market each year as a result of population growth."

(5) During the period of recession and recovery from 1929 to 1935, the number of salaried employees was reduced 20.9 percent and the number of wage earners 16.5 percent. (In absolute numbers wage earners decreased by 1,460,000 while total employment in man-hours per week fell 35.7 percent, about 152,000,000 man-hours per week). The decline in employment between 1929 and 1935 was due in part to the failure of manufacturing production to regain the pre-depression level and in part to an advance in industrial productivity that enabled a smaller working force to produce a given volume of output. The extent of the decline in employment due to advance in productivity in manufacturing industries, Dr. Mills measures in accordance with Methods A and B suggested by Dr. Jerome.[60] These computations indicate that:

(*a*) The 1929 level of output could have been produced in 1935, with man-hour output equal to that prevailing in 1935, with 91,292,000 man-hours less. With a working week of 48.3 hours (that of 1929), this would have meant the employment of 1,882,000 workers less than in 1929. This measures the potential loss in employment as a result of advancing productivity, when no account is taken of changes in working hours or in demand.

(*b*) Of the total decline of 152,425,000 man-hours in aggregate man-hours worked per week between 1929 and 1935, approximately 74,664,000 man-hours (or 49 percent) was directly associated with rising productivity. In other words, it took 74,664,000 man-hours per week less in 1935 than it would have taken in 1929, to produce the volume of manufactured goods turned out in 1935.

(*c*) With the 1935 working week of 37.2 hours and with the 1935 rate of man-hour output, the 1929 level of production would have required in 1935 some 200,000 workers more than were actually employed in manufacturing industries in 1929 (9,022,000 workers as against 8,839,000). This means that the reduction in working hours between 1929 and 1935 more than counterbalanced the loss of employment that might have resulted from rising productivity, if the sole effect of productivity gains had been the displacement of workers.

(*d*) The record of employment changes from 1929 to 1935 shows the persistence of the tendencies noted between 1919 and 1929; that is, the wants of consumers of manufactured goods could be met, on the established level, with a steadily declining quantity of human labor. Labor time was being released as a result of steady advances in productivity.

(6) Comparing the 15 groups into which the manufacturing industries of the United States are classified by the Bureau of the Census, Dr. Mills finds that the heaviest decline in employment (as measured by number of workers) between 1929 and 1935 occurred in the non-consumption goods industries, that is, in industries producing capital goods, construction goods, and producer supplies. Comparing changes in volume of production, productivity, number of wage earners and aggregate man-hours per week between 1929 and 1935, Dr.

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[60] See pp. ——, supra.

Mills finds that employment, whether measured in man-hours or in number of wage earners employed, suffered smaller losses among consumption goods, in which productivity advanced substantially, than among capital goods and construction materials, in which the gain in productivity was smaller.

(7) Comparing the actual decline in aggregate man-hours between 1929 and 1935 with the decline in number of man-hours required to produce the 1935 volume of output, Dr. Mills computes that the loss of aggregate employment attributable to productivity changes constituted some 87 percent of the total employment loss in the industries producing human consumption goods, about 15 and 10 percent in industries producing capital equipment and construction materials, respectively. In the latter two groups of industries, technological changes were thus a minor factor in the loss of employment.

(8) Summing up Dr. Mills says: "Of the actual employment decline in man-hours in manufacturing industries between 1929 and 1935, slightly less than half appears to be attributable to changes in industrial productivity, the remainder is apparently attributable to the decline in production * * * The persistence of reduced industrial activity and the complex market conditions that underlie this reduction are in a causal sense more important than increased man-hour productivity as factors in the employment decline since 1929." He observes further: "The 8,839,000 workers in manufacturing industries in 1929 could in 1935 have produced the 1929 output with a work week 10.3 hours shorter than in 1929. The 1929 work week averaged 48.3 hours. The reduction justified by advance in productivity if all the gain were to be realized in the form of leisure would have meant a workweek of 38 hours. The actual workweek in 1935 averaged 37.2 hours. The program of shorter hours represented in effect the allocation to leisure or enforced idleness of all the gains of advancing productivity plus something more."

(9) The situation in 1938 seemed darker than in 1935. Clearly, we are faced with a serious problem of adaptation to changing conditions of production and employment in manufacturing industries made necessary by technological changes. "Something of a redirection of productive resources, particularly the annual additions to the working population, may be necessitated by the cumulative technical improvements that have been steadily increasing industrial productivity. This redirection, which may mean the reversal of a movement into manufacturing and mechanical occupations that has grown steadily during the whole course of our national history, is perhaps at the heart of the problem. It involves issues transcending manufacturing industries alone."

THE MEASUREMENT OF REEMPLOYMENT OPPORTUNITIES

The persistence of a large volume of unemployment and the continued discussion of technological unemployment led the Works Progress Administration to set up as one of its projects a large-scale study of the effects of technological changes on production and employment. This study, known as the National Research Project, has been in progress since 1936 to date under the direction of Mr. David Weintraub.

It is impossible, within the limits of this volume, to undertake a detailed review of the entire research output of the N. R. P. This output has been very large and has made an important contribution to the store of factual data needed for an understanding of the industrial and economic effects of technological change. From the point of view of the present survey, however, what is of particular interest is the attempt made by the N. R. P. to measure changes in labor productivity resulting from technological improvements as a basis for estimating the possibilities of reemployment. From this point of view, two reports are of special interest, namely: The report on Unemployment and Increasing Productivity, published in June 1937; and the report on Production, Employment, and Productivity, published in May 1939. In considering these two reports, it is necessary to

stress the fact that they represent a part only of the N. R. P. contribution to the study of the subject. The two reports will be considered separately.

UNEMPLOYMENT AND INCREASING PRODUCTIVITY

The problem set by this study [61] is to measure, for the period 1920 through 1935, the over-all changes within the total economic order of the quantity of labor required to produce a given amount of national income. The authors are fully aware that a complete investigation of the effects of changing technology on the volume of employment and unemployment "would involve an analysis of the effects of changing prices of goods and services, of changing costs of capital and labor and * * * of changing demands for goods and services, and of a multitude of other factors which play an important part in determining the profitableness of employing workers." They are also aware that, "only such an economic analysis, dealing with the fundamental elements of our economic society," is capable of arriving at "conclusions concerning the underlying causes of unemployment in general and the particular type of unemployment which might be attributed to changing industrial techniques." [62]

However, expressly disclaiming any effort to engage in such a complete analysis, the authors confine themselves to an examination of the available statistical information on the volume of production and employment since 1920 in the light of the changes in output per man-year which took place during the period. The aim of the study is thus limited to measuring the year-to-year changes in the ratio between the total national income and the total volume of employment.

To measure annual changes in the productivity of the national economy as a whole, the authors proceed by devising indexes of overall production and overall employment. They make no attempt to measure the physical volume of production directly by the technique of attributing weights to individual series of index numbers representing the output of specified goods (steel, cement, coal, electric power, cotton cloth, etc.) and of specified services (e. g. ton-miles of freight hauled by railroads). Instead, the total volume of production in any year is taken as equal to the dollar value of national income produced—i. e., to the net value of goods and services for final consumption produced through "efforts whose results appear on the market place of our economy." [63] To eliminate the distortions arising from changes in the purchasing power of money (rising or falling price levels), the figures on national income [64] are deflated by use of an index purporting to represent "prices of finished goods." [65] As the authors expressly indicate, the deflator used is one which gives "insufficient importance * * * to consumers' services and 'nonessentials' which con-

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[61] David Weintraub, assisted by Harold L. Posner, "Unemployment and Increasing Productivity," ch. V, in Technological Trends and National Policy, National Resources Committee, June 1937, pp. 67–87.

[62] Ibid., p. 67.

[63] Ibid., p. 68.

[64] For 1920–29, the figures on national income are derived from "realized income" less "imputed income" plus "business savings" as shown in Leven, Moulton and Warburton, America's Capacity to Consume. For 1929–35, the figures on "national income" are taken from the estimates of the U. S. Department of Commerce as shown in Survey of Current Business, July 1936, excluding income from work relief. The Brookings series is spliced to the Commerce series in 1929. Ibid., p. 69.

[65] Ibid., p. 68.

stituted an increasing proportion of the national income produced over the period"[66] (1920–35).

As for the index of employment, it is restricted to the employment of "hired labor employed in the creation of this national product."[67] It would also be well to bear in mind, as the authors stress, that employment and unemployment statistics are "rather fragmentary" for the period prior to 1930. The following main steps were taken in developing the index of employment:

A. From the census figures on "gainfully occupied persons" in 1920 and in 1930 there were subtracted all enterprisers, all self-employed workers, and all unpaid family workers on farms.[68] The results were taken to express, for 1920 and 1930, the "national labor force" or total "supply of labor for hire."

B. Taking account of the flow of immigration, emigration, and farm-city movements, estimated figures on the total supply of labor for hire were interpolated for each of the intercensal years between 1920 and 1930.[69]

C. For the years 1931 through 1935, the total supply of labor for hire was estimated by adjusting the 1930 census figures for changes in the age distribution of the population, immigration, and emigration, and farm-city movements. The total supply for these years therefore includes young persons "who under 'normal' conditions would have obtained their first employment experience, but who, during the period of widespread unemployment, may never have worked."[70]

D. From the figures on the total of the country's supply of labor for hire in each year there was subtracted 2.5 percent in order to deflate the total for workers "actually not available for work because of illness, vacations, voluntary transfers between jobs, labor disputes, and similar reasons for idleness."[71] The remainder is taken to represent "the country's total manpower available for hire."[72]

E. From the annual figures on total manpower available for hire estimates were derived of the annual number of "man-years" of employment and unemployment.[73] These estimates make use of a large body of statistical data (developed by various governmental agencies) purporting to represent year-to-year fluctuations in the volume of employment in particular groups of industries.[74] In order to adjust for workers em-

[66] Idem. The index of the "prices of finished goods" used for adjusting price changes is derived by giving weights of 1 and 9, respectively, to: (a) The cost of capital goods; (b) the B. L. S. cost-of-living index. (Idem, footnote 7.)

[67] Ibid., p. 68.

[68] Ibid., p. 69. This procedure is explained by stating that the report "concerns itself only with the effects of changing productivity on the employment opportunities of those who depend upon paid jobs for their livelihood and are, therefore, subject to unemployment." (Idem.)

[69] Idem.

[70] Ibid., pp. 69–70.

On the other hand, no account was seemingly taken of possible contractions in the total supply of labor attributable to child labor restrictions, retirement and pension schemes, limitations on the employment of women in industry, etc.

[71] Ibid., p. 70.

The deflator is explained on the ground that the 1930 census data on unemployment indicated that about 2.5 percent of all "workers" were "unusable" for the reasons specified.

[72] P. 10, idem.

[73] Ibid., p. 71.

[74] The figures used are those developed by the U. S. Bureau of the Census, the U. S. Bureau of Mines, the U. S. Bureau of Labor Statistics, the Interstate Commerce Commission, the Ohio State Department of Industrial Relations.

ployed only part-time in the day or week and for workers employed only part of the year, the available data were reduced to "full time equivalents" or "man-years" by utilizing the results of certain studies on the amount of time lost by part-time workers in particular years.[75]

F. No attempt was made to translate the "man-year" of work, given the average hours of work that prevailed in particular years, into "man-hours." The purpose of the study was to consider the number of jobs available rather than the number of man-hours required; "* * * it was therefore considered appropriate to use each year's prevailing hour content as representing a man-year of work and to make the part-time adjustments with this flexible man-year concept in mind." [76]

The main results of the report may be summarized as follows:

1. In 1935 as compared with 1920, production rose 14 percent while employment fell 18 percent; an increase of 39 percent in labor productivity or a decrease of 28 percent in unit labor requirements. This means that the same amount of labor was 39 percent more productive of national income in 1935 than in 1920. Conversely, the same amount of national income required 28 percent less labor for its production in 1935 than in 1920.[77]
2. Between 1920 and 1929, production expanded as much as 46 percent, while employment increased only 16 percent. The productivity of a man-year therefore went up 26 percent; conversely, the labor requirement for a unit of output went down 21 percent. All or most of the improvement in productivity took place "during the depression of 1921 and the recovery of 1922.[78] Thereafter, from 1922 through 1929, productivity fluctuated within narrow limits on a plateau from 20 to 30 percent above the level of 1920, as shown below:

Year	1920=100	
	Productivity	Unit labor requirement [1]
1922	126	79
1923	120	84
1924	123	81
1925	127	79
1926	124	81
1927	123	81
1928	129	78
1929	126	79

[1] Ibid., table 3, p. 72.

3. Between 1929 and 1932 production contracted about 40 percent while employment decreased 37 percent, thereby resulting in a slight decrease of productivity (5 percent) or increase of unit labor requirement (5 percent). From 1932

[75] Studies made in Columbus, Buffalo, Syracuse, and Louisville at various times from 1920 through 1936. (Ibid., p. 71, footnote 11.)
[76] Ibid., p. 71.
[77] Ibid., pp. 71–72.
[78] Ibid., pp. 14, 72.

to 1935, however, production expanded 27 percent while employment grew only 12 percent, thereby resulting in a considerable improvement of productivity (rise of 16 percent) or unit labor requirement (fall of 11 percent).[79]

4. Comparing the net change between 1929 and 1935, the following results emerge:

	Percent
The production of national income declined	21
The employment of man-years declined	29
The amount of national income produced, per man-year of employment, rose	10
The amount of employment required, per unit of national income, fell	9

Taken at face value, these figures suggest that it would not have been possible to return to the 1929 level of employment in 1935 until and unless the output of goods and services was 40 percent greater than the amount actually obtained; i. e. 10 percent greater than the output of 1929.[80] Because of the growth of employable population over the period, it would not have been possible to return to the 1929 level of unemployment in 1935 until and unless the output of goods and services was 55 percent greater than the amount actually obtained in 1935, or 20 percent greater than the output of 1929.[81] A great expansion of output was therefore necessary in 1935 before employment could be raised or unemployment lowered to the levels of 1929.

Recognizing the great practical difficulties of isolating the technological factor in labor productivity, the authors of the report are careful to explain that the extent to which heightened labor productivity may have diminished employment opportunities in 1935 as compared with 1929 does not measure the extent of increased "technological unemployment" over the period in question.[82] Throughout their report, in fact, the authors stress the practical impossibility of measuring the volume of technological unemployment and warn against the uncritical use of figures on improved labor productivity as expressive of technological changes to the exclusion of other factors. To quote but a few of their statements on this point:

> Except in very rare cases, the effect of strictly technical changes on employment in a single industry or even a single plant cannot be isolated.[83]
>
> To measure the full effect of even a single technological change on displacement and absorption (of labor) would * * * necessitate the virtually impossible task of tracing it through the innumerable factors which bear on the total volume of production and employment.
>
> Making direct inquiry among employers and workers would not be feasible either, since frequently neither the worker who loses his job nor the employer who lays him off knows whether the lay-off is the result of technological improvement or not.[84]

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[79] Idem.
[80] Ibid., p. 78.
[81] Idem.
[82] "The (over-all) productivity ratios * * * can be regarded as indicative of the effects of technological change only in the broadest sense. These over-all productivity ratios (quantity output per unit of hired-labor time) reflect a variety of factors in addition to the mechanical improvements usually characterized as 'technological.' Thus productivity may change as a result of non-mechanical aids to labor, or managerial improvements, or in response to varying degrees of utilization of productive capacity, or changes in the hours of work, or any combination of these and other factors. On the other hand, technological improvements are frequently made without any resulting changes in the productivity ratio, although they may cause changes in the occupational requirements of the industry directly concerned or of a related industry." (Ibid., p. 79.)
[83] Idem.
[84] Ibid., pp. 80–81.

No satisfactory method of measuring the effect of technological changes on employment has yet been evolved. The complexity of the interrelationships between industries and between productivity and production makes impossible an adequate quantitative description of the full effects of technological developments.[85]

Disclaiming, therefore, any effort to measure technological unemployment, the authors present figures for the period 1920–35 on what they designate as "unrealized employment." The measure of unrealized employment is the difference between the total number of jobs available in any one year and the number which would have been required for the production of that year's total output had the over-all productivity remained at the previous year's level. This procedure necessitates "treating the national economy as a single industry and measuring the net effects of changes in output and productivity." Fundamental to the procedure, as the authors recognize, is the assumption that changes in productivity are independent of changes in volume of production; an assumption which they believe it safe to make when comparing successive years.[86]

Subject to this assumption, the available statistics are examined with a view to answering the question: "How much of any year's unemployment may be ascribed to the difference between the number of jobs available that year and the number which would have been required for the production of that year's output had the productivity remained at the level of the year immediately preceding it?" [87]

The results reached for the period 1920–35 may be summarized as follows:

	Man-years of "unrealized employment" as percent of [1]—				Man-years of "unrealized employment" as percent of [1]—		
	Employment in 1920	Each year's employment	Each year's unemployment		Employment in 1920	Each year's employment	Each year's unemployment
1920	(2)	(2)	(2)	1928	5	5	33
1921	9	11	34	1929	(3)	(3)	(3)
1922	12	14	49	1930	(3)	(3)	(3)
1923	(3)	(3)	(3)	1931	2	2	4
1924	3	3	19	1932	(3)	(3)	(3)
1925	3	3	19	1933	8	12	14
1926	(3)	(3)	(3)	1934	(3)	(3)	(3)
1927	(3)	(3)	(3)	1935	3	4	5

[1] Ibid., table 9, p. 82.
[2] Not available.
[3] No "unrealized" employment; productivity declined or was unchanged.

On the basis of these figures, the authors conclude that: "During the period surveyed, except for the period after 1929, when the sharp decline in output resulted in a tremendous increase in unemployment, 'unrealized' employment constituted from one-fifth to one-half of the unemployed manpower in years when over-all productivity increased." [88] It is essential to stress that these figures on year-to-year movements of "unrealized" employment "do not constitute measures of the number of 'technologically unemployed' workers" in any

[85] Ibid., p. 82.
[86] "If the periods chosen for comparison are relatively close, * * * say two successive years, the error resulting from an assumption of independence between changes in productivity and the volume of production is held to a minimum." (Ibid., p. 81.)
[87] Idem.
[88] Ibid., p. 82.

year.[89] At most, these figures may be used to measure roughly the effect upon unemployment totals of heightened productivity, regardless of the factors contributing to that heightened productivity.

In concluding, the authors make it clear that their figures "cannot be used either to affirm or deny any particular theory" of the impact of technological change upon the disemployment or displacement of workers in modern industrial society. Their major, though limited, finding is that an "undetermined but substantial proportion of the unemployed in any single year (1920–35) probably consisted of workers who had been displaced from their jobs in one way or another by the employment dislocations which accompany technological progress." [90]

As for the outlook in the immediate future of reemploying workers disemployed by the impact of technological improvement, the report is guardedly pessimistic:

> The outlook for the immediate future seems to be in the direction of further technological progress toward a level of productivity substantially higher than that attained prior to 1929. The rate of advance, of course, differs in different industries, but since our economic system has not evinced an ability to make the necessary adjustments fast enough, it may be expected that the dislocations occasioned by technological progress will continue to present serious problems of industrial, economic, and social readjustments.[91]

PRODUCTION, EMPLOYMENT, AND PRODUCTIVITY IN MANUFACTURING INDUSTRY [92]

This report also derives from the N. R. P.'s main purpose of examining the relationship between changes in productivity and reemployment opportunities. Instead, however, of considering the national economy as a whole, it takes up separately each of 59 manufacturing industries. For each of these industries the authors consider the data on production and employment during the post-war years with a view to deriving for individual industries useful indexes of labor productivity and of unit labor requirements.[93] The findings for the 59 industries, taken together, are regarded as representative, within narrow margins, of the findings that would be obtained from a study of manufacturing industries in their entirety.

It is necessary to point out that the report is concerned with developing proper measures of productivity, not with analyzing the causes underlying changes of productivity in manufacturing industry since 1919. As the authors state:

> The report does not concern itself with reasons for the changes that have occurred since 1919 in production, employment, man-hours, and productivity for the 59 manufacturing industries surveyed. The movements of production and productivity may be due to a number of factors arising from the economics and techniques of an industry. For example, productivity may change as a result of changes in technology, plant lay-out, managerial technique, efficiency of individual or groups of workers, degree of utilization of capacity, raw materials, or the quality of the products manufactured; productivity may also change as a conse-

[89] Idem.
[90] Ibid., pp. 86–87.
[91] Ibid., p. 87.
[92] This report was prepared by Harry Magdoff, I. H. Siegel and M. B. Davis; its exact title is Production, Employment, and Productivity in 59 Manufacturing Industries, 1919–36. It consists of three parts published in three separate volumes: Pt. I—Purpose, Methods, and Summary of Findings; Pt. II—Indexes for individual Industries and Methods of Construction; Pt. III—Appendixes. The report was published in May 1939.
[93] Ibid., pt. I, Preface.

quence of the mortality of inefficient and old plants and the entrance of new and more efficient ones or as a consequence of the shift in production between plants producing at different productivity levels. An analysis of the effects of changes in productivity on employment opportunities and the relationship of changes in production to changes in productivity requires intensive studies of individual industries, strategic sections of the economy, and the conditions and development of the economy as a whole. The report * * * is * * * confined to the task of measurement (that is) primarily with the construction of measures which are pertinent to and useful in a study of production and productivity changes and their bearing on employment prospects.[94]

While limiting their aims, the authors relate their report to the general purposes of the N. R. P. inquiry.

The central question concerning unemployment today is whether the current unemployment problem is of a different nature from the problem in the past. The question is, in part, one of the changing structure of the economy and the relationship of this factor to the prospects of future employment. *Within this context, the bearing of the changing productivity of labor on the total volume of labor utilized is of particular interest.*[95]

They go on to claim that the ratio of total output to total man-hours or man-years, despite admitted shortcomings, affords a useful measure of the impact of changing industrial techniques on employment opportunities. They write:

The mere computation of changes in a ratio of quantity produced to labor time consumed does not, of course, establish a significant economic relationship between production and employment. Measures of the type presented in this report do, however, permit the *gaging of trends in employment opportunities.* Despite the fact that changes in the degree of plant capacity utilization are known to affect labor productivity, that the incidence of changes in industrial techniques differs according to the size of plants, or that computed changes in output per unit of labor may reflect changes in the relative quantities of different products, the conclusion which must be drawn after a careful examination of the data for a large number of manufacturing industries is that the *observed trend in labor productivity reflects principally the effects of the continuous changes in industrial techniques on the amount of labor required per unit of output.* The annual figures * * * must, of course, be approached with caution; not only the factors mentioned above, but many others besides technological change may have influenced the level of any industry's productivity figure for a particular year.[96]

To measure productivity changes between 1919 and 1936, the authors selected 59 manufacturing industries for which adequate statistics of production and employment were available.[97] Broadly speaking, an industry was defined as an aggregation of establishments producing either a single product (where comparable labor statistics were available for that product) or in most cases, as an aggregation of establishments manufacturing "the smallest possible combination of products," for which comparable production and employment indexes could be constructed.

The N. R. P. production indexes were built up in three steps: by individual manufacturing industries; by individual groups of industries; by all industries combined. Ignoring the years for which interpolation was necessary and considering only the years for which primary data were available in the Census of Manufactures, in the

[94] Ibid., p. 2.
[95] Ibid., p. 3. [Italics supplied.]
[96] Ibid., p. XIV. [Italics supplied.]
[97] With a few exceptions, the 59 manufacturing industries as defined in this study are identical with, or equivalent to, corresponding industries as defined in the biennial Census of Manufactures. Ibid., pp. 21-24.

Yearbook of Agriculture, in the reports of the Bureau of Mines, etc., the following procedure was followed:

Individual industries: Where the industry produced some single uniform product—e. g., beet or cane sugar, cement, cigarettes, beehive or byproduct coke, etc.—production for the year was taken as equal to the physical quantity of output[98]—pounds, tons, etc.—reported in the official statistics. In some instances moreover, several products were counted as a single product: e. g., total gallons of ice cream plus other ices; total tonnage of pig-iron plus ferro-alloys. In the case of petroleum products, because no other means of computation was practicable, production was taken as equal to input—i. e., the volume of crude petroleum refined.

For the great majority of industries, however, the production of the industry could be determined only by adding together—properly weighted—the production of a great many diverse products.

In every case where an industry manufactured a diversity of products, the problem arose of how to weigh the individual items so as to arrive at the total production for a given year. Although the output of each such item was always available in some quantitative measure—pounds, tons, gallons, yards, barrels, bales, cases, number—it was possible only in a few cases to obtain figures on the relative labor requirements of the individual commodities making up the production composite of a given manufacturing industry.[99] Weights derived from value of output data had, therefore, to be used as the best available substitute for weights derived from labor requirement data; in most cases, the value weights were determined from the figures for 1929.[1]

The next step was to obtain a combined index of production for each of 13 industry groups.[2] With regard to every industry forming part of a given group, the production indexes had already been determined; it therefore merely remained to weight the individual indexes in order to obtain an overall index for each industrial group. By drawing upon official statistics from many sources, it was possible to obtain proper weights from data on wage earners employed and man-hours expended in 1929 and in other years for each of the 13 groups.

To arrive at a production index for the 59 manufacturing industries combined, the production indexes of 13 industry groups and of 24 manufacturing industries not forming part of a group[3] were

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[98] Ideally, total output; by necessity in most cases, however, output for sale.

[99] National Research Project, Production, Employment, and Productivity in 59 Manufacturing Industries, 1919–36, Part I, p. 37.

[1] Ibid., pp. 38–39.

[2] (1) Bread and other bakery products group (biscuit and crackers; bakery products other than biscuit and crackers); (2) canning and preserving group (canned and preserved fruits and vegetables; canned and cured fish); (3) coke group (beehive coke; by-product coke); (4) glass group (window glass; plate glass; glass containers; pressed and blown ware); (5) iron and steel group (blast furnaces; steel works and rolling mills); (6) knit goods group (hosiery, underwear, outerwear, knit cloth); (7) leather group (sole and harness leather; side and upholstery leather; calfskin; kid leather; sheep and miscellaneous leather); (8) lumber and timber products group (logging camps); sawmills and saw-plane mills); (9) nonferrous metals group (primary smelters and refineries; secondary smelters and refineries; alloyers, rolling mills and foundries); (10) paper and pulp group (paper; pulp); (11) rubber products group (rubber tires and inner tubes; other rubber goods; (12) tobacco products group (cigars; cigarettes; chewing and smoking tobacco and snuff); (13) woolen and worsted goods group (woolen goods; worsted goods).

[3] (1) Agricultural implements; (2) beet sugar; (3) boots and shoes; (4) cane sugar refining; (5) cement; (6) chemicals; (7) clay products (other than pottery) and non-clay refractories; (8) confectionery; (9) cotton goods; (10) electric lamps; (11) fertilizers; (12) flour and other grain-mill products; (13) furniture; (14) ice cream; (15) manufactured gas; (16) manufactured ice; (17) motor vehicles; (18) newspaper and periodical printing and publishing; (19) paints and varnishes; (20) petroleum refining; (21) planing-mill products; (22) rayon; (23) silk and rayon goods; (24) slaughtering and meat packing.

weighted by substantially the same procedure as that used to determine the production index for an individual group of industries.

In computing employment indexes which could be applied against the production indexes for particular manufacturing industries so as to yield productivity ratios, it was decided to restrict the count of employment to wage earners. All salaried employees were excluded, not only "because they are not so directly engaged in the processes of production as are wage earners" but also because "no statistical series reflecting their specific output were available." [4]

It must be stressed that every employment index covered by the N. R. P. series is restricted to wage earners as distinguished from salaried employees. The productivity ratios do not, therefore, measure the productivity of the entire labor force. What they do measure, strictly speaking, is the productivity of manual wage earners, i. e., the ratio of all the man-hours or man-years of manual labor in manufacturing plants to the entire output produced by the joint labor of wage earners and salaried employees.

To obtain the count of wage earners, the authors of the study resorted to the Census of Manufactures, which in odd-numbered years—1919, 1921 * * * 1935—gives figures, from which annual averages may be derived on employment in each month of the year for particular manufacturing industries. These figures were supplemented—for interpolation and adjustment purposes—by the continuous monthly employment indexes published by the Bureau of Labor Statistics and by the National Industrial Conference Board as well as by figures obtained from the Bureau of Mines and from State publications.[5]

Absence of adequate direct statistics on man-hours expended made it necessary to estimate the annual man-hour totals in the employment series for all but a handful of industries.[6] The procedure was to multiply the average annual employment of wage earners in a given industry by the average actual hours of work (not the "prevailing" work-week or "fulltime" hours). The necessary figures were obtained from the compilations of the Bureau of Labor Statistics and the National Industrial Conference Board.[7]

The representative character of the manufacturing industries selected for analysis by the N. R. P. is particularly important in view of the conclusions that might be drawn from the overall indexes of production, employment, and productivity for the 59 manufacturing industries combined. In 1929, the 59 industries selected for anlysis employed more than 4.5 million wage earners, or about 51 percent of the total wage earners reported by the Census of Manufactures; they manufactured products to a value of almost $40,000,000,000 or about 56 percent of the total value of the products manufactured by all reporting industries. Throughout the period 1919–36, the N. R. P. sample consistently accounted for about half (49 to 54 percent) of all the wage earners employed in manufacturing as reported by the Census of Manufactures.[8]

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[4] National Research Project, Production, Employment, and Productivity in 59 Manufacturing Industries, 1919–36, pt. I, p. 42.

[5] Ibid., pp. 43–47.

[6] For three industries, however—beehive coke, by-product coke and electric lamps—it was possible to compute the indexes directly from man-hour totals as officially compiled. (Ibid., p. 49.)

[7] Ibid., pp. 51–56.

[8] Ibid., pp. 60–61.

On the other hand, the N. R. P. sample suffers from an admitted defect in that it fails to give adequate representation to capital goods industries as distinct from consumer goods industries. This leads the authors to observe with regard to the overall indexes of production, employment, and productivity for the 59 manufacturing industries combined:

* * * such indexes are more likely to indicate the *direction* of the year-to-year percentage changes for all manufacturing than the *correct* magniture of these changes.[9]

The two census groups which are under-represented most seriously in the N. R. P. sample are (1) machinery other than transportation equipment, and (2) railroad repair shops. Railroad repair shops are excluded completely from the sample; machinery other than transportation equipment is covered to the extent of not more than 4 percent of wage earners or value of products (1929). Furthermore, the important industry of shipbuilding is excluded from the industries covered in the census group—transportation equipment, air, land, and water.[10]

Changes in Productivity, Output, and Employment for All Industries Combined, 1919–36.

Combining all 59 manufacturing industries, the authors, calculate two series of productivity indexes: (A) which describes changes in the amount of labor required each year in order to obtain a fixed composite of production—that of 1929; and (B) which describes the changes since 1929 in the amount of labor required each year in order to obtain a changing composite of production—that of the current year. These series are shown in the tables which follow:

From table I (fixed composite of production), three phases in the movement of productivity may be distinguished: 1919–29, 1929–32, and 1932–36.

1919–28: The index for output per wage earner rose 55 percent and that for output per man-hour 57 percent.

In other words, with the unit labor requirements of 1919 approximately 55 percent more wage earners and 57 percent more man-hours would have been necessary to produce the 1929 composite of products.

In fact, however, while production increased, employment and man-hours remained below the 1919 level throughout most of this period. Thus—

* * * a major characteristic of the manufacturing industries [11] * * * was the production of an increasing amount of goods with a relatively stable or even declining volume of employment * * *.[12] The average hours worked per week changed little during the period under consideration * * * [so that] * * * the indexes of employment and man-hours are similar until 1929.[13]

[9] Ibid., pp. 61–62 [italics supplied.]
[10] Ibid., pp. 61–63.
[11] Other than the capital goods industries, it should be understood.
[12] Employment of wage earners as distinct from salaried employees.
[13] National Research Project: Production, Employment, and Productivity in 59 Manufacturing Industries, 1919–36, Part I, p. 64.

TABLE I.—*Combined indexes of production, employment, man-hours, and productivity (with base-year man-hour weights), for N. R. P. manufacturing industries: 1919–36*[1]

[1929=100]

Year	Production[2]	Employment	Man-hours	Output per— Wage earner	Output per— Man-hour
1919	63.4	98.4	99.9	64.4	63.5
1920	67.3	100.5	100.5	67.0	67.0
1921	54.3	78.8	75.9	68.9	71.5
1922	70.4	91.7	91.5	76.8	76.9
1923	81.7	100.7	100.7	81.1	81.1
1924	77.4	94.8	92.1	81.6	84.0
1925	86.1	98.2	97.5	87.7	88.3
1926	90.2	98.8	98.7	91.3	91.4
1927	88.5	95.6	95.7	92.6	92.5
1928	93.0	96.3	96.0	96.6	96.9
1929	100.0	100.0	100.0	100.0	100.0
1930	80.8	86.3	80.1	93.6	100.9
1931	68.0	73.2	65.2	92.9	104.3
1932	53.4	64.4	51.8	82.9	103.1
1933	62.1	72.6	57.7	85.5	107.6
1934	67.1	84.0	60.5	79.9	110.9
1935	77.9	86.9	65.7	89.6	118.6
1936	89.3	90.9	73.3	98.2	121.8

[1] For many industries data are lacking for some of the years of the period 1919–36. Hence the index numbers were constructed by chaining links for identical industries.
[2] Equivalent to an index whose component indexes were weighted with changing man-hour weights.

Source: Works Progress Administration. National Research Project, Production, Employment, and Productivity in 59 Manufacturing Industries, 1919–36, Part I, table XI, p. 65.

Between 1929 and 1932 production declined 47 percent, the number of wage earners 36 percent, and the number of man-hours 48 percent. In other words, output per wage earner declined as the averaged hours worked dropped, but output per man-hour remained fairly stable and even increased slightly. By 1936, production had recovered to 89 percent of the 1929 level and employment to 91 percent, but the index of man-hours was still 27 units below. Output per wage earner was only slightly below 1929, but output per man-hour had reached a point 22 percent above 1929 [a divergence resulting from the decline of average hours per week] [14]

[14] Ibid., pp. 64–66.

TABLE II.—*Combined indexes of production, employment, man-hours, and productivity (with changing man-hour weights) for N. R. P. manufacturing industries. 1919–36*

[1929=100]

Year	Production [2]	Employment	Man-hours	Output per— Wage earner	Man-hour
1919	69.0	98.4	99.9	70.1	69.1
1920	72.4	100.5	100.5	72.0	72.0
1921	58.6	78.8	75.9	74.4	77.2
1922	73.3	91.7	91.5	79.9	80.1
1923	83.4	100.7	100.7	82.8	82.8
1924	78.8	94.8	92.1	83.1	85.6
1925	87.1	98.2	97.5	88.7	89.3
1926	90.7	98.8	98.7	91.8	91.9
1927	89.2	95.6	95.7	93.3	93.2
1928	93.3	96.3	96.0	96.9	97.2
1929	100.0	100.0	100.0	100.0	100.0
1930	81.0	86.3	80.1	93.9	101.1
1931	69.3	73.2	65.2	94.7	106.3
1932	55.8	64.4	51.8	86.6	107.7
1933	65.5	72.6	57.7	90.2	113.5
1934	68.7	84.0	60.5	81.8	113.6
1935	80.4	86.9	65.7	92.5	122.4
1936	90.8	90.9	73.3	99.9	123.9

[1] See table I, footnote (a).
[2] Equivalent to an index whose component indexes were weighted with base-year man-hour weights.

Source: Works Progress Administration, National Research Project, Production, Employment and Productivity in 59 Manufacturing Industries, 1919–36, Part I, table XIII, p. 67.

As may be seen by comparing tables I and II, the movement of the productivity index for a fixed composite of production does not fully correspond to the movement of the productivity index for a changing composite of production. The extent of this divergence may be made clear by putting the two indexes side by side as in table III below where A gives the indexes for a production composite fixed as of the base year 1929; and B gives the indexes for a production composite changing as of each year.

TABLE III.—*Indexes of productivity, 1919–36*

[1929=100]

Year	Output per wage earner A	Output per wage earner B	Output per man-hour A	Output per man-hour B	Year	Output per wage earner A	Output per wage earner B	Output per man-hour A	Output per man-hour B
1919	64.4	70.1	63.5	69.1	1928	96.6	96.9	96.9	97.2
1920	67.0	72.0	67.0	72.0	1929	100.0	100.0	100.0	100.0
1921	68.9	74.4	71.5	77.2	1930	93.6	93.9	100.9	101.1
1922	76.8	79.9	76.9	80.1	1931	92.9	94.7	104.3	106.3
1923	81.1	82.8	81.1	82.8	1932	82.9	86.6	103.1	107.7
1924	81.6	83.1	84.0	85.6	1933	85.5	90.2	107.6	113.5
1925	87.7	88.7	88.3	89.3	1934	79.9	81.8	110.9	113.6
1926	91.3	91.8	91.4	91.9	1935	89.6	92.5	118.6	122.4
1927	92.6	93.3	92.5	93.2	1936	98.2	99.9	121.8	123.9

Source: Tables I and II, supra.

The authors explain the divergence (of magnitude, not direction) for 1919 as compared with 1929 and for 1932 or 1936 as compared with 1929, as follows:

1919 compared with 1929:

> * * * in general, production advanced at higher rates in industries registering the greater gains in productivity. In other words, those industries which experienced a more rapid rise in production received relatively more weight in the 1929 composite than in the 1919 composite; since it was these industries which had the more rapid rise in output per man hour, * * * [which] were weighted more heavily in the fixed-weight index with 1929 weights than in the changing-weight index with 1919 weights. Hence the index with 1929 weights shows a higher percentage increase in output per man-hour from 1919 to 1920 [about 59 percent] than does the index with changing weights [about 45 percent].[15]

1932 or 1936 compared with 1929:

> Output per man-hour for the fixed composite rose 3 percent from 1929 to 1932; it rose 22 percent from 1929 to 1936. The corresponding increases for the changing composite were 8 and 24 percent, respectively. The difference * * * for the period 1929–32 is due to the association, in general, of declining output per man-hour in industries with the sharper declines in production and increasing output per man-hour in industries with less severe reductions in output. While not true in every instance, the durable-goods industries not only suffered sharper declines in production between 1929 and 1932 but also were characterized by fairly stable or even declining output per man-hour. On the other hand, production in the non-durable-goods industries, in general, decreased less while output per man-hour rose. Since the indexes of output per man-hour for the latter industries were weighted more heavily in the production composite following 1929 than in 1929, the productivity measure with changing weights is higher than the index with fixed weights in 1932.[16]

On the other hand—

> estimates of the man-hour requirements based on either index would not differ greatly after 1929. * * * By 1936, the difference was only two points (or less than 2 percent).[17]

Changes in Production, Employment, and Productivity in Individual Industries, 1919–1936.

The authors then proceed to consider the average annual rates of change in production, employment, and productivity for individual manufacturing industries.[18] Making separate computations for various periods regarded as particularly significant, they present and discuss a series of tables which indicate (*a*) the number of industries experiencing specified average annual rates of change in production, employment, man-hours, output per wage earner, and output per man-hour; and (*b*) the percentage of all manufacturing wage earners employed in 1929 who were employed by industries experiencing specified average annual rates of change in production, employment, man hours, output per wage earner and output per man-hour.

With regard to the period 1919 to 1929, for example, it is found that the following percentages of all wage earners employed in 59 manufacturing industries in 1929, were employed by manufacturing industries where output per wage earner and output per man-hour

[15] Ibid., pp. 66–67.
[16] Ibid., pp. 67–68.
[17] Ibid., p. 69.
[18] The authors again point out here that their study is limited to a statistical analysis only. They state: "Study of the differences between the individual parts of the total is necessary for an inquiry into the relationships between changes in productivity, in technology, and in economic factors; it also serves to facilitate estimates of future employment opportunities. An intensive study of these factors would require a detailed analysis of strategic classes of industries in their relation to the changing structure of the economy and their behavior under varying economic conditions. *Such studies were outside the scope of this report*, but a statistical analysis of the movements of production, employment, and productivity of the individual industries constitutes a necessary preliminary step." (Ibid., p. 69.) [Italics supplied.]

underwent specified average annual rates of increase from 1919 to 1929:

Productivity increasing at average annual rate of not less than—	Percentage distribution of 1929 employment—specified increase of—	
	Output per wage-earner	Output per man-hour
	Percent	*Percent*
12.6 percent		
10.1 percent	2.1	2.1
7.6 percent	15.1	15.1
5.1 percent	26.9	36.3
2.6 percent	61.5	62.3
0.1 percent	[1] 99.7	[2] 92.3

[1] The balance of the wage earners—0.3 percent—were employed in manufacturing industries where output per wage earner declined from 0.1 to 2.5 percent annually.
[2] The balance of the wage earners—7.7 percent—were employed in manufacturing industries where output per man-hour declined from 0.1 to 2.5 percent annually.

Source: Works Progress Administration, National Research Project, Production, Employment, and Productivity in 59 Manufacturing Industries, 1919–36, pt. I, table XV, p. 73.

With regard to the period 1929–35, in contrast, it is found that the following percentages of all wage earners employed in 59 manufacturing industries in 1929 were employed by manufacturing industries where output per wage earner and output per man-hour underwent specified annual average rates of increase or decrease from 1929 to 1935:

Productivity increasing at annual average rate of not less than—	Percentage distribution of 1929 employment—specified increase or decrease of—	
	Output per wage-earner	Output per man-hour
	Percent	*Percent*
12.6 percent		0.9
10.1 percent		2.3
7.6 percent	0.9	5.5
5.1 percent	2.3	23.2
2.6 percent	4.6	55.9
0.1 percent	28.1	92.1
Productivity decreasing at annual average rate of not more than:.		
2.5 percent	39.1	6.2
5.0 percent	58.0	7.8
7.5 percent	71.8	7.9
Industries of increasing productivity	28.1	92.1
Industries of decreasing productivity	71.8	7.9
Total	[1] 99.9	100.0

[1] The balance of the wage earners—0.1 percent—were employed in manufacturing industries where output per wage earner declined more than 10.0 percent annually.

Source: Works Progress Administration, National Research Project, Production, Employment, and Productivity in 59 Manufacturing Industries, 1919–36, pt. I, table XVI, p. 75.

What these figures bring out is that: (1) Output per man-hour was increasing steadily for practically all wage earners employed in manufacturing industries between 1929 and 1935 as well as between 1919 and 1929, although at somewhat higher annual rates during the the earlier period than during the later period; (2) output per wage earner increased for virtually all wage earners employed in manufacturing industries between 1919 and 1929 at annual rates not far below the rates of increase for output per man-hour. (This parallelism reflects almost unchanged weekly working hours throughout the period); (3) output per wage earner decreased between 1929 and 1935

in manufacturing industries employing about 70 percent of the wage earners in 1929 and increased only in manufacturing industries employing about 30 percent of the wage earners. (This divergence from output per man-hour reflects considerable shortening of the work-week.) In other words, what individual manufacturing industries lost between 1929 and 1935 in their power to employ labor (because man-hour output rose) was entirely offset in the bulk of those industries by the widespread movement toward a shorter work-week.

General Conclusions and Comments.

The most significant broad result reached by the study is that in 1936 as compared with 1929, postulating the 1929 composite of production in each year, output per man-hour in 59 manufacturing industries was about 22 percent greater, output per wage earner about 2 percent smaller.[19] Translating into unit labor requirements, this means that if the output of 1929 had been literally reproduced in 1936 (the same commodities in the same amounts) but using the industrial techniques of 1936, instead of those of 1929—then (*a*) for each 100 man-hours expended in 1929, it would have been necessary to expend not more than 82 man-hours in 1936; but (*b*) for each 100 wage earners employed in 1929, it would have been necessary to employ almost 102 wage earners in 1936. In terms of the changed production composite, however, that of 1936, it would have taken 100 man-hours in 1929 to reproduce the amount and kind of output that 82 man-hours were actually producing in 1936; but about an equal number of workers would have been employed in both years.[20]

If, therefore, the findings for the 59 industries may be regarded as affording a true measure of how the reemployment potential of manufacturing industry was affected between 1929 and 1936, it follows that the shortening of the work-week added just about enough to that potential to offset what increased labor productivity took away—no more, no less. As for the immediate future, the authors of the report are not very optimistic regarding the possibilities of liquidating in manufacturing industries unemployment on a large scale. They state:

> The probability for the future seems to be that there will be less rather than more employment in manufacturing industries. Should manufacturing industries reach and sustain the 1929 level of output within the next few years, the average number of wage earners required will not far exceed, if at all, the average number employed in 1929, despite the 20-percent reduction in the average number of hours worked per week that occurred between 1929 and 1936. In the longer run, since output per man-hour seems certain to increase further, manufacturing employment will probably be below that of 1929. Only a great increase in production or a marked decline in hours worked per week could bring manufacturing employment to levels appreciably higher than 1929. It is well to recall, however, that even the 50-percent increase in output between 1919 and 1929 left the average number of wage earners in manufacturing almost stationary.[21]

As has been repeatedly indicated here, the report summarized above represents a major contribution to the statistical analysis of employment and unemployment. The indexes developed by the authors for 59 manufacturing industries from 1919 to 1936 indicate clearly a continuous rise in labor productivity of such magnitude as to affect the capacity of manufacturing industry to employ the whole of the labor force attached to it or that might otherwise seek employment in it.

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[19] See table I, supra.
[20] See table II, supra.
[21] Works Progress Administration, National Research Project, Production, Employment, and Productivity in 59 Manufacturing Industries, 1919–36, Part I, p. 82.

PART II

TECHNOLOGY AND ECONOMIC BALANCE

A study of technological advance and the compensatory forces of reduction in working hours, the creation of new industries, and the reduction of prices.

TECHNOLOGY AND ECONOMIC BALANCE

INTRODUCTION

Part I of this report analyzed technology as to its importance in the history of economic thought. In this part attention is directed to the present development of modern technology and the economic problems it creates.

Technology, which may be defined as the application of the analytical methods of science to the industrial arts, creates a primary economic problem through its displacement of human effort.

Three aspects of this labor-displacing problem are examined here:

1. The measurement of the change in labor productivity;
2. The types of labor-saving techniques which have brought about the change; and
3. The effects of the change upon labor and the economy as a whole.

Presumably, there are certain compensatory forces inherent in the present economic order which operate more or less automatically to offset the labor-displacing effects of technology. Principal among them are the reduction of hours (without an accompanying decline in wages), the development of new industries, and the reduction of prices.

A balance is theoretically supposed to exist between the advance in labor productivity and these compensatory forces. If labor-displacement should prove greater than these compensatory forces, the scale would tip toward greater unemployment, less use of our economic resources and increased social distress. When such unbalance persists, the most far-reaching consequences emerge.

An investigation of the social and political consequences of such unbalance is obviously beyond the scope of a report limited, as is this, to economic analysis. But it is interesting to note the existence of this same economic phenomenon of unbalance in Germany. Manifestly, technological displacement was not the sole or even the prime cause of social and political upheavals there nor do such changes inevitably follow the persistence of technological unemployment. There can be little doubt, however, that a large and apparently growing body of unemployed in pre-Hitler Germany furnished a fertile field for social change and that much of the unemployment was due to technological displacement of labor.[1]

The persistence of mass unemployment in the United States, despite marked economic recovery, and the growing emphasis on technological advance should cause grave concern to all thoughtful persons who seek the preservation of democracy.

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[1] Cf. International Labour Office, The Social Aspects of Rationalisation, Geneva, 1931, pp. 245–50; and Three Sources of Unemployment, Geneva, 1935, pp. 78–100.

CHAPTER I

THE CHANGE IN LABOR PRODUCTIVITY

THE EXTENT OF THE CHANGE

A first purpose of this part of the study is to measure the extent of the increase in labor productivity. That less labor is required from year to year to produce a given amount of goods is widely observed, but appraisal of the extent of the change depends upon accurate measurement.

Output per man-hour is the most accurate measure of labor productivity because reductions in hours or changes in price do not affect its validity. Labor is regarded simply as the number of hours worked.[1] Since output per man-hour is a quotient of the indexes of production and of man-hours, the validity of the labor productivity series depends entirely upon the validity of the indexes used as divisor and dividend.

It has been possible to obtain comparable production and man-hour series in manufacturing, steam railroads, bituminous coal mining, and anthracite mining from 1923 to date and, except in the case of steam railroads, for the census years 1909, 1914, and 1919.[2] The trend of output per man-hour in each of these four segments of the economy is compared with production in chart I, table 1.

Labor productivity in these four fields has made striking advances, reaching an all-time high in 1939. It has been relatively unaffected by the major cyclical downturns and, except for a few brief interruptions, has steadily increased. The principal variation in the productivity trend has been in its rate of advance, and in three of the fields the rate has greatly accelerated in the last decade.

The changes in production and productivity occurring between the years 1923–29 and 1929–39 in the same four segments of the economy are compared in chart II, table 2. These periods are compared to show the relative changes in production and productivity in the prosperous twenties (1923 being the first comparatively normal year following the post-war depression) and in the past decade of depression and recovery.

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[1] For a discussion of various statistical techniques used to indicate the change in labor productivity, see appendix A.

[2] For their sources, see appendix B.

TABLE 1.—*Indexes of production and productivity, 1909–39*

[1923=100]

Year	Manufacturing		Steam railroads		Bituminous coal mining		Anthracite mining	
	Production	Output per man-hour	Production	Output per man-hour	Production	Output per man-hour	Production	Output per man-hour
1909	56.5	66.2	----------	----------	67.2	70.1	86.9	81.9
1914	66.5	76.4	69.8	78.2	74.9	77.8	97.3	86.8
1919	79.3	76.4	94.8	88.6	82.5	85.8	94.4	96.6
1923	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0
1924	94.3	105.8	94.3	103.0	85.6	101.7	94.2	94.4
1925	106.5	113.2	99.2	108.5	92.1	101.0	66.2	94.9
1926	112.5	116.9	104.8	111.1	101.6	100.3	90.5	95.4
1927	113.3	120.8	101.0	110.8	91.7	101.6	85.9	98.3
1928	121.2	129.5	100.8	116.3	88.7	105.3	80.7	98.1
1929	130.1	131.9	103.3	118.2	94.7	108.1	79.1	96.4
1930	107.6	131.6	88.7	118.0	82.8	112.8	74.3	94.0
1931	93.7	141.3	71.6	118.8	67.7	118.0	63.9	100.2
1932	71.1	137.7	54.4	116.1	54.8	115.9	53.4	115.0
1933	81.7	144.8	57.0	129.3	59.1	110.0	53.0	126.4
1934	89.1	147.9	61.7	130.1	63.6	111.9	61.3	118.5
1935	107.7	158.8	64.6	135.9	65.9	115.4	55.9	121.3
1936	127.6	161.8	77.8	145.7	77.8	121.5	58.5	135.1
1937	134.4	157.5	83.1	148.5	78.9	124.8	55.6	142.8
1938	103.6	159.8	67.7	146.8	60.6	130.4	49.4	166.1
1939	129.5	174.5	76.7	154.9	69.1	142.1	54.4	172.6

Source: Witt Bowden, "Wages, Hours and Productivity of Industrial Labor, 1909–39", U. S. Bureau of Labor Statistics, Monthly Labor Review, September 1940. Production figures computed by Witt Bowden for derivation of output per man-hour indexes. Original data for manufacturing from the National Bureau of Economic Research, Federal Reserve Board, and the U. S. Bureau of Labor Statistics; for Steam Railroads from the Interstate Commerce Commission; and for Bituminous and Anthracite Mining from the U. S. Bureau of Mines and the U. S. Bureau of Labor Statistics.

TABLE 2.—*Percent change in production and labor productivity, 1923–29 and 1929–39*

Period	Production	Man-hour output	Period	Production	Man-hour output
MANUFACTURING					
1923–29	+30.1	+31.9	1929–39	−0.5	+32.3
STEAM RAILROADS					
1923–29	+3.3	+18.2	1929–39	−25.8	+31.0
BITUMINOUS COAL MINING					
1923–29	−5.3	+8.1	1929–39	−27.0	+31.5
ANTHRACITE MINING					
1923–29	−20.9	−3.6	1929–39	−31.2	+79.0

Source: Table 1, supra.

The advance in labor productivity during 1923–29 concided rather closely with the increase in production, but in the latter period a wide divergence developed between the trends of productivity and production. In the earlier period an increase of 31.9 percent in labor productivity in manufacturing was matched by a rise of 30.1 percent in production. In bituminous coal mining, labor produc-

CHART I

PRODUCTION AND PRODUCTIVITY IN THE UNITED STATES

SELECTED INDUSTRIES FOR SELECTED YEARS

1909-1939

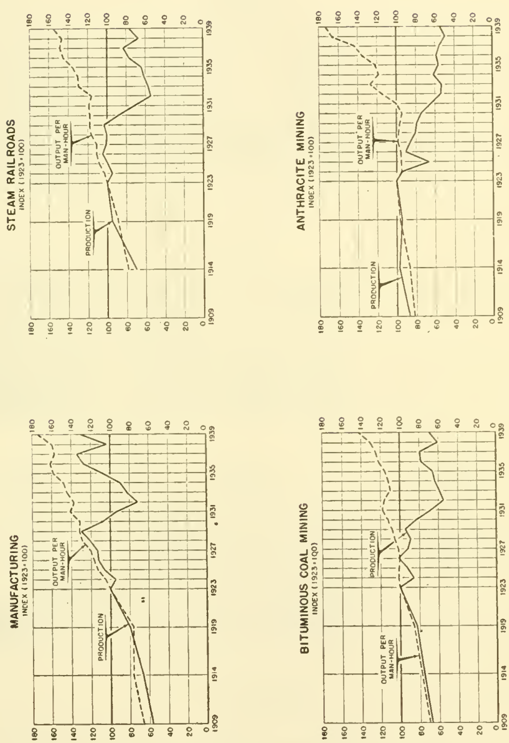
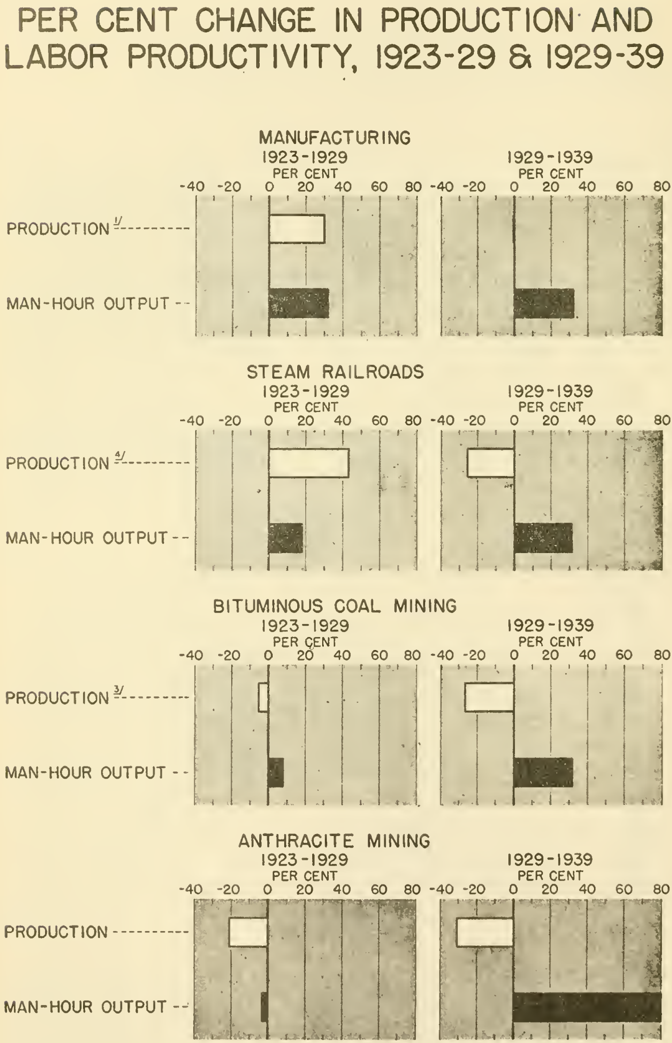


CHART II


PER CENT CHANGE IN PRODUCTION AND LABOR PRODUCTIVITY, 1923-29 & 1929-39
MANUFACTURING
1923-1929
1929-1939
PER CENT
-40 -20 0 20 40 60 80
PRODUCTION 1/
MAN-HOUR OUTPUT
STEAM RAILROADS
PRODUCTION 4/
BITUMINOUS COAL MINING
PRODUCTION 3/
ANTHRACITE MINING
PRODUCTION

tivity remained remarkably stable, increasing only 8.1 percent, but production decreased 5.3 percent. Labor productivity in anthracite mining, actually declined 3.6 percent, while production went down 20.9 percent. In steam railroads, an increase of 18.2 percent in labor productivity was accompanied by a rise of 3.3 percent in production.

But during 1929–39 the pattern was entirely changed. Declines in production were coupled with remarkable advances in labor productivity. In manufacturing, productivity advanced 32.3 percent while production went down 0.5 percent. In bituminous coal, labor productivity increased 31.5 percent but production declined 27.0 percent. In anthracite mining a similar decline in production (31.2 percent) was overbalanced by an increase in labor productivity of 79.0 percent. In steam railroads, labor productivity went up 31.1 percent while production declined 25.8 percent.

Labor productivity in three of the fields increased much more rapidly during 1929–39 than during 1923–29. In bituminous coal mining, productivity advanced 8.1 percent during 1923–29 but rose 31.5 percent during 1929–39; in anthracite mining, it actually declined 3.6 percent in the former period but increased 79.0 percent during the latter; and in steam railroads, it rose 18.2 percent in the earlier period but gained even more (31.1 percent) in the latter. Only in manufacturing was the increase in labor productivity in 1923–29 at all comparable with that of 1929–39. This long-term increase in labor productivity is remarkable because increases in output per man-hour occurring between 1929 and 1939 were achieved despite a level of output lower in the latter than in the former year.

Of equal interest is the extent of the changes in labor productivity in specific manufacturing industries. The National Research Project on Reemployment Opportunities and Recent Changes in Industrial Techniques, organized by the Works Progress Administration in 1935, has formulated indexes of wage-hour and man-hour productivity for a large number of industries.[3]

The changes in productivity, indicated by these series, are shown for 40 manufacturing industries in chart III, table 3.[4] Changes are indicated from the base year, 1923, to 1929 and 1936 for each of the industries. It was possible to project the series forward for 15 of the industries and thus the chart indicates also the percentage change to 1939 in 13 of those industries, to 1938 in one and to 1937 in the other.

Productivity increased in each of these industries over the base year in both 1929 and 1936. It likewise increased between 1929 and 1936 in most of the industries. In contrast, production in 1936 was below the 1929 level in 26 of the 40 industries as reported by the National Research Project. Despite this generally lower level of production, output per man-hour in 34 industries was higher in 1936 than in 1929, strikingly indicating the intensity and rapidity with which technological improvements were introduced during that 7-year period.

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[3] Production, Employment, and Productivity in 59 Manufacturing Industries, 1919–36, by Harry Magdoff, Irving H. Siegel, and Milton B. Davis, May 1939.

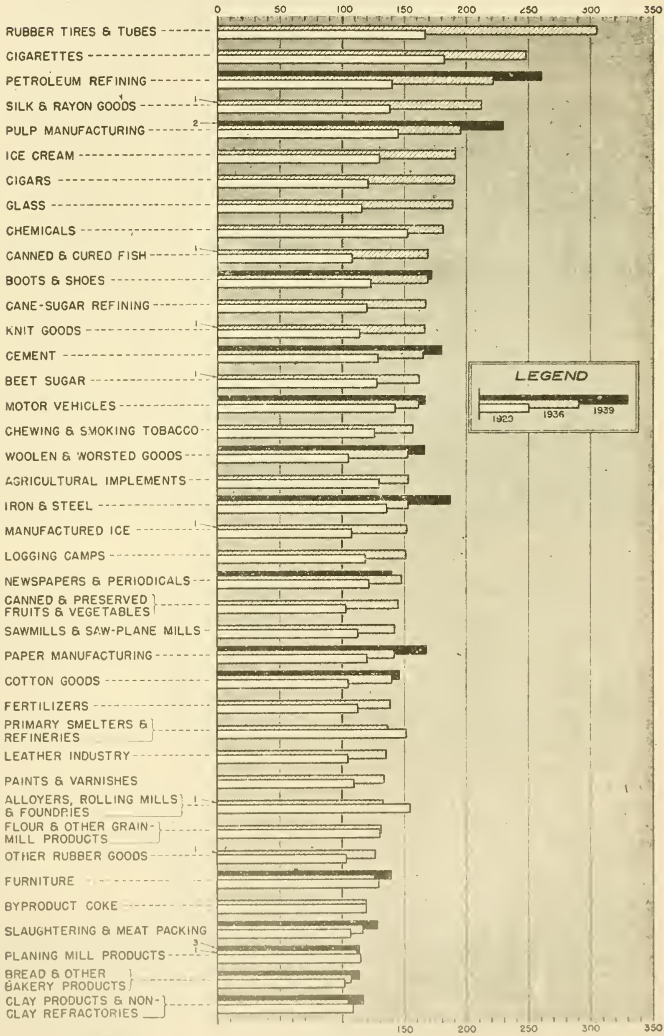
[4] Wherever possible, data were secured relating to specific industries rather than to industry groups. In certain cases, such as the hosiery, underwear, outerwear, and knit-cloth industries, productivity data are available only as output per wage-earner, while output per man-hour figures are available for the industry group, knit goods. In the case of leather, the industry group is utilized, though man-hour data were available for component segments of that group, in order not to overbalance the table and chart by the inclusion of five specific leather industries. Also, such relatively minor industries as beehive coke and secondary smelters and refineries were omitted from the chart. For a brief discussion of the adequacy of these series, see appendix C.

CHART III

PERCENTAGE CHANGES IN OUTPUT PER MAN-HOUR

40 MANUFACTURING INDUSTRIES

INDEX (1923=100)



Source: Table 8

TABLE 3.—*Indexes of output per man-hour 1929, 1936, 1939: 40 manufacturing industries*

[1923=100]

Industry	1929	1936	1939
Agricultural implements	130.4	153.8	
Beet sugar	127.9	[1] 162.4	
Boots and shoes	123.5	168.8	172.5
Bread and other bakery products	120.7	107.7	113.8
Cane-sugar refining	102.0	167.2	
Canned and preserved fruit and vegetables	103.6	145.6	
Canned and cured fish	108.7	[1] 169.2	
Cement	129.0	165.5	180.0
Chemicals	153.6	181.6	
Clay products, other than pottery	109.5	105.0	117.1
Cotton goods	105.3	139.9	146.7
Fertilizers	113.6	138.9	
Flour and other grain-mill products	131.4	132.6	
Furniture	130.0	126.5	140.3
Glass	116.3	188.8	
Ice cream	129.9	190.8	
Iron and steel	136.6	153.0	187.2
Knit goods	114.4	[1] 166.2	
Byproduct coke	120.0	119.9	
Leather	105.8	136.0	
Logging camps	119.0	151.7	
Sawmills and saw-plane mills	113.5	142.8	
Manufactured ice	108.0	[1] 152.8	
Motor vehicles	143.3	161.3	166.9
Newspapers and periodicals	122.4	148.1	140.0
Primary smelters and refineries	152.0	136.9	
Alloyers, rolling mills and foundries	155.3	[1] 133.2	
Paints and varnishes	110.1	133.8	
Paper manufacturing	120.2	142.8	168.1
Pulp manufacturing	145.1	195.2	[2] 229.7
Petroleum refining	140.1	221.0	259.9
Planing mill products	115.2	[1] 112.0	[3] 114.7
Rubber tires and tubes	167.2	304.7	
Other rubber goods	104.4	[1] 127.7	
Silk and rayon goods	138.3	[1] 212.0	
Slaughtering and meat packing	107.0	117.8	129.4
Cigars	121.7	190.4	
Cigarettes	182.5	248.7	
Chewing and smoking tobacco	126.3	157.1	
Woolen and worsted goods	105.7	153.7	166.1

[1] 1935. [2] 1938. [3] 1937.

Source: National Research Project, Works Progress Administration, Production, Employment and Productivity in 59 Manufacturing Industries, 1919–36, Part II. The 1939 figures were projected by the National Research Project staff and transmitted by letter to the Temporary National Economic Committee. For the 15 industries with 1939 figures the 1936 figures are revised.

Five of the six industries in which productivity fell between 1929 and 1936 suffered extensive declines in production, with a less severe decline in the sixth. The 1936 production index (1929=100) for the six industries follows: [5]

Planing-mill products (1935)	45.2
Alloyers, rolling mills, and foundries (1935)	53.9
Clay products	54.1
Primary smelters and refineries	64.3
Furniture	66.5
Byproduct coke	82.9

From 1936 to 1939 labor productivity continued its upward trend in all but one of the 15 industries for which the series have been projected. In newspaper and periodical printing and publishing the decline in labor productivity may be partially due to the decrease in output, the index of production falling 3.0 percent between 1936 and 1939. In the other industries (except motor vehicles) production was at a higher level in 1939 (or the last year for which data were available) than in 1936.

[5] Works Progress Administration, National Research Project, Production, Employment, and Productivity in 59 Manufacturing Industries, 1919–36, Part II.

Of particular interest are the extensive increases in labor productivity occurring in four industries. In the rubber tires and tubes industry, labor productivity in 1936 was 204.7 percent above the 1923 level; in petroleum refining, in 1939 it was 159.9 percent above 1923; in 1936 in cigarette manufacture it was 148.7 percent above the base year; and in 1939, in pulp manufacturing, it was 129.7 percent above the base year. Although the increasing use of these commodities was undoubtedly a primary cause of the advance in labor productivity, it is significant that three of these industries use chemical methods in production. The increasing use of chemical processes in productive operations[6] probably portends a rapid increase in productivity in the fields where such processes are applied.

TYPES OF LABOR-SAVING TECHNIQUES

Before describing the various types of labor-saving techniques, attention should be called to two circumstances, under either of which labor productivity would tend to increase in practically any situation.

(1) Labor productivity tends to advance as a greater degree of standardization is achieved. The smaller the variety of goods made by a given unit of productive equipment the greater the productivity of the labor involved.

Any calculation of the savings resulting from standardization necessitates a determination of the economies of mass production and the fraction of such economies due to standardization. Such figures are almost impossible of verification, but in certain cases the economies attendant upon standardization are known to be great.[7]

A case showing the way in which standardization increases labor productivity is that of the Jantzen knitting mills; this firm formerly produced sweaters, coats, caps, stockings and many other varieties of knitwear but in 1927 decided to make swimming suits of only one quality on a large scale. Upon this transition there occurred a phenomenal increase in productivity. Prior to the introduction of the standardization program an operator turned out an average of 9 seams per hour. After its adoption, the worker produced 45 seams per hour with no greater effort.[8]

The widespread acceptance of standardization in the United States is indicated in a recent publication of the National Bureau of Standards, Reductions in Varieties Effected by the Application of Simpli-

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[6] For further discussion, see pp. 112–113, infra.

[7] The National Industrial Conference Board in its study, Industrial Standardization, observed that, "The automobile industry may have saved \$750,000,000 a year through standardization; the lumber industry, \$250,000,000 a year; and the brick industry, \$1,000,000 a year; the building industry may have lost \$2,000,000,000 by lack of standardization, but there seems to be no conceivable way of checking up on the figures."

As an example of the economies caused by standardization in one case, the National Industrial Conference Board cited an American manufacturer of motor car parts. "He was practically operating on a job-shop basis, although his total output was large enough to warrant quantity-production economies. Careful figuring showed him that he could cut his price in half, improve his delivery service, and yet make more money himself, if he could induce all his customers to accept the same pattern. He laid the facts before them. They accepted the proposal. One of them saved \$4,000,000 a year, or \$20 a part on 200,000 parts." National Industrial Conference Board, Inc., Industrial Standardization, New York 1929, pp. 166, 171.

[8] E. C. Robbins and F. E. Folts, Introduction to Industrial Management, McGraw-Hill, New York, 1933, pp. 61–62.

In the United States, the number of types of electrical lamps was reduced from 55,000 in 1900 to 342 in 1923 by the standardization of voltages and bases. The Commercial Standards Monthly observed that, "This eliminating of types had made it possible to develop and adopt high-speed machinery for lamp making. These machines eliminated practically all costly hand operations and made better lamps in larger quantities and at lower prices." ("Simplification and Standardization within the Electric Lamp Industry," Commercial Standards Monthly, August 1930, p. 46.)

fication Practices. The number of varieties before and after simplification and the resulting percentage reductions are presented for a large number of commodities in appendix D. The savings in unit labor expenditures which these reductions represent are suggested by the specific instances cited.

(2) Labor productivity also tends to rise with increasing production. The tendency for unit costs to decline as the rate of operation advances is a well-known characteristic of most industries and requires no elaboration at this point. The applicability of this principle is qualified (a) by the existence in every form of activity of a point of diminishing returns, after which costs cease to decline with further increases in production, and (b) by the existence of certain "increasing cost" industries, particularly in the extractive fields.

The general tendency of labor required per unit to decline as the percent of capacity utilized increases is shown in chart IV, table 4, for three fields in which such data are available: Iron and steel, cement, and brick and tile.[9]

It is difficult to classify the various types of labor-saving techniques because of their interdependency. For example, certain chemical processes which have greatly reduced labor requirements could not have been applied without the development of certain new materials such as alloy steels. Similarly, few types of machinery perform only one labor-saving function; for example, those that increase speed frequently also eliminate hand operations. Because of this interdependency any classification, such as the following, is presented solely for purposes of convenience. It helps to clarify the labor-saving effects of certain technological changes and to emphasize the number of ways in which technology increases the productivity of labor.

TABLE 4.—*Effect of variations in capacity utilization upon man-hours required*

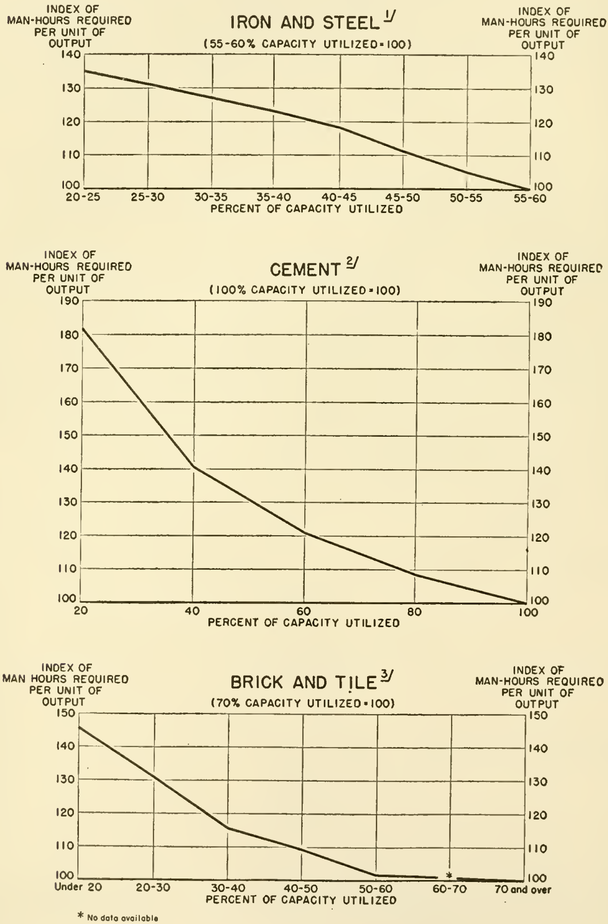
Industry	Percent of capacity utilized	Man-hours required per unit of output
Iron and steel	55 to 60	100
	50 to 55	105
	45 to 50	111
	40 to 45	118
	35 to 40	123
	30 to 35	127
	25 to 30	131
	20 to 25	135
Cement	100	100.0
	80	108.6
	60	120.8
	40	140.4
	20	181.4
Brick and tile	70 and over	100.0
	60 to 69.99	----
	50 to 59.99	101.5
	40 to 49.99	109.2
	30 to 39.99	115.4
	20 to 29.99	130.9
	Less than 20	145.5

Sources:
Iron and Steel: U. S. Bureau of Labor Statistics, Monthly Labor Review, vol. 40, May 1935, p. 1161.
Cement: Work Projects Administration, National Research Project, Mechanization in the Cement Industry, 1939, p. 23.
Brick and tile: Works Progress Administration, National Research Project, Productivity and Employment in Selected Industries, Brick and Tile. 1939. p. 117

[9] There are two basic limitations to these data. First, the iron and steel and brick and tile analyses extend only to 55–60 percent and 70 and over percent of capacity utilized. respectively. Second, since 1935, when the iron and steel study was made, the continuous process has been widely substituted in rolling mills for the semi- and non-continuous process. Under the continuous process the decline in man-hour requirements with increasing capacity utilization is probably even more pronounced.

Chart IV

EFFECT OF VARIATIONS IN CAPACITY UTILIZATION UPON MAN-HOURS REQUIRED PER UNIT OF OUTPUT



[1] Bureau of Labor Statistics, Monthly Labor Review, vol. 40, May 1935, p. 1161.
[2] National Research Project, Mechanization in the Cement Industry, 1939, p. 23.
[3] National Research Project, Productivity and Employment in Selected Industries, Brick and Tile, 1939, p. 117.

TYPES OF LABOR-SAVING TECHNIQUES

1. Power and energy development.[10]
2. Materials:
   (a) Substitute materials.
   (b) Improved materials.
3. Processes:
   (a) Mechanical [11] (including multiple-function machinery).
   (b) Nonmechanical.
4. Individual single-function machinery (grouped according to primacy of function):
   (a) Elimination of operation.
   (b) Increase of speed.
   (c) Enlargement of capacity.
5. Management methods:
   (a) The human factor.
   (b) The material conditions of manufacture.

A procedure followed by the United States Patent Office was adopted in the classification: Under each of the five major types are included all labor-saving techniques pertaining to it except those which might be included in any of the preceding groupings. Thus the substitution of fuel oil for coal could not be placed under the "Materials" heading because it primarily belongs under the preceding heading of "Power and Energy Development." Though the classification in outline form is limited in usefulness, specific examples are given in the discussion to illustrate the various types of techniques.

POWER AND ENERGY DEVELOPMENT

Power is primary to all productive operations. The story of technological progress is in no small part the history of the development and use of new and improved forms of power. At first man used his own brute strength and increased it with wedge and lever, pulley and plane, cog and treadmill. He domesticated animals and trained them to use their strength at his command. The winds and running water provided transportation and the motive power for mills to grind the grains of the earth, to hammer metals into shape, and even to operate complex machinery. Then came the practical application of steam as a source of power in removing water from mines, and in running continuously the already developed machines of the textile industry. And today steam itself is feeling the inroads of other forms of power.

As the forms of power change, a concomitant change in the fuels from which power is derived takes place. Electricity and natural gas are replacing steam, and in the generation of steam, fuel oil is replacing coal. Of primary importance among the many innovations which have reduced the amount of labor required to produce a unit of energy (a British thermal unit) has been the

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[10] All products, processes, and machines for converting into power the sources of energy.
[11] Those that achieve a change in the product without a chemical reaction or a direct use of electric energy (not including electric energy as a source of power or heat).

substitution of fuel oil, natural gas, and hydroelectric power for coal. The use of each of these substitute fuels has been steadily increasing, with marked effects upon labor productivity. It is the purpose of this section to discuss substitutions of one fuel for another and of new processes for obtaining greater energy from an existent fuel, rather than to analyze mechanical changes which have increased the productivity of labor engaged in extracting any particular fuel.

The encroachment of fuel oil upon the bituminous coal market is in no small measure due to the methods of marketing fuel oil. It is a residual product of petroleum distillation and is sold at very low prices merely to dispose of a byproduct formerly considered waste. Figures published annually by a petroleum authority, Joseph E. Pogue, indicate that fuel oils are sold at Oklahoma refineries for less than is paid for the crude petroleum from which the fuel oil is produced.[12]

The increasing industrial use of natural gas is likewise due in large part to the low rates gas producers offer industrial users to secure equalized outlets for pipe-line loads. "On the average, these 'industrial' gas rates are about one-fourth or one-fifth of the rates charged domestic or household users, and in some localities the domestic rate in as much as 10 times the industrial rate."[13]

The development by the Federal Government of large hydroelectric power projects which set a yardstick of low rates to both domestic and industrial users has undoubtedly adversely affected the market for coal though thousands of persons have derived benefits from this cheaper electric power.

The extent to which fuel oil, natural gas, and hydroelectric power have been substituted for coal since 1923 is indicated in chart V, table 5. In 1923 these fuels encroached upon only 18.5 percent of the possible coal market; by 1938 the proportion had risen to 36.9 percent.

This increasing use of other fuels has resulted in material declines in the amount of coal actually produced. It has been estimated that between 1923 and 1938 approximately 810,126,000 tons of coal were displaced by these other three fuels.[14] The replacement of coal by other fuels is pertinent to this study because the production of the substitute fuels involves much less labor per unit of energy than does coal. Each ton of bituminous coal mined in the United States costs in wages approximately $1.27. Four barrels of fuel oil (fuel equivalent of 1 ton of coal) can be produced for a labor cost of about 68 cents. The production of 20,000 cubic feet of natural gas (fuel equivalent of 1 ton of coal) costs about 8 cents in wages. The production of 2,000 kilowatt-hours of hydroelectric power (energy equivalent to that produced by a ton of coal) costs less than 1 cent for labor.[15] In the words of Thomas Kennedy, secretary and treasurer of the United Mine Workers of America:

[12] Testimony of Charles O'Neill, president, United Eastern Coal Sales Corporation, in hearings before the Temporary National Economic Committee, Pt. 30, Technology and Concentration of Economic Power, p. 17519.

As the distance from the refinery increases, the chances for the maintenance of low fuel oil prices are lessened, either because of high transportation charges (shortly after the beginning of the second World War tanker rates from the Gulf to the eastern seaboard rose several hundred percent) or of practices pursued by distributors.

[13] Ibid., p. 17519.

[14] Ibid., p. 17529.

[15] Ibid., p. 17520.

As against competing fuels labor plays a very important part in the production of coal * * *. Oil, gas, etc., come from practically laborless industries.[16]

TABLE 5.—*Consumption of bituminous coal, coal equivalent of fuel oil and natural gas, and output of hydroelectric power reduced to coal equivalent, 1923–38*

[Thousands of net tons]

Year	Bituminous coal consumed (net tons)	Per-cent of total	Fuel oil consumed in coal equivalent (net tons)	Per-cent of total	Natural gas consumed in coal equivalent (net tons)	Per-cent of total	Output of hydroelectric power reduced to coal equivalent on basis current efficiency rate for steam generation (net tons)	Per-cent of total	Total
1923	518, 993	81. 5	66, 599	10. 5	27, 740	4. 4	23, 212	3. 6	636, 544
1924	484, 004	79. 4	74, 038	12. 2	29, 577	4. 8	21, 666	3 6	609, 285
1925	499. 193	78. 1	85, 287	13. 3	31, 227	4. 9	23, 474	3. 7	639, 181
1926	532, 581	78. 5	85, 319	12. 6	35, 217	5. 2	25, 534	3. 7	678, 651
1927	499, 801	76. 5	88, 450	13. 5	37, 585	5. 8	27, 485	4. 2	653, 321
1928	498, 828	74. 7	97, 519	14. 6	40, 957	6. 1	30, 532	4. 6	667, 836
1929	519, 555	74. 3	102, 403	14. 7	47, 563	6. 8	29, 262	4. 2	698, 783
1930	454, 990	73. 4	90, 532	14. 6	47. 593	7. 7	26, 747	4. 3	619, 862
1931	371, 869	70. 8	83, 667	15. 9	45, 874	8. 8	23, 717	4. 5	525, 127
1932	306, 917	67. 8	77, 039	17. 0	42. 836	9. 5	25, 574	5. 7	452, 366
1933	321, 617	68. 5	79, 086	16. 8	43, 608	9. 3	25, 524	5. 4	469, 835
1934	347, 043	68. 6	85, 093	16. 8	49, 029	9. 7	25, 033	4. 9	506, 198
1935	360, 292	67. 3	91, 681	17. 1	54, 395	10. 2	29, 177	5. 4	535, 545
1936	422, 796	68. 4	102, 660	16. 6	62. 931	10. 2	29, 475	4. 8	617, 862
1937	428, 496	66. 9	110, 589	17. 3	70, 532	11. 0	31, 028	4. 8	640, 645
1938	340, 735	63. 1	102, 304	18. 9	65, 814	12. 2	31, 295	5. 8	540, 148
Total	6, 907, 710	------	1, 422, 266	------	732, 478	------	428, 735	------	9, 491, 189

Source: Hearings before the Temporary National Economic Committee, Part 30, exhibit 2737, table 5.

Of the estimated 74,540 jobs lost by miners between 1923 and 1937 in the coal industry because of the use of substitute fuels, only a very small portion has been made up by labor expended in producing substitute fuels. The bulk of the labor displaced by substitute fuels must be regarded as a net displacement. The total loss of employment by the coal industry from all causes between 1923 and 1937 is shown in table 6.

Steps have been taken to decrease the amount of coal required to perform a given amount of work in an effort to maintain its competitive position. By better grading and sorting and more careful analysis of the conditions of coal utilization marked improvements have been made in its efficiency, and the productivity of labor involved has thereby been increased.

In 1920 the average number of pounds of coal per thousand gross ton-miles in freight services on steam railroads was 172; by 1938 it was only 115, a reduction of 33.1 percent, or a reduction in use of 25,998,982 tons for 1938.

The pounds of coal per passenger train car-mile between 1920 and 1938 were reduced from 18.8 to 14.9, a decrease of 20.7 percent, or a reduction in use of 5,546,165 tons for 1938.[17]

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[16] Ibid., p. 17191.

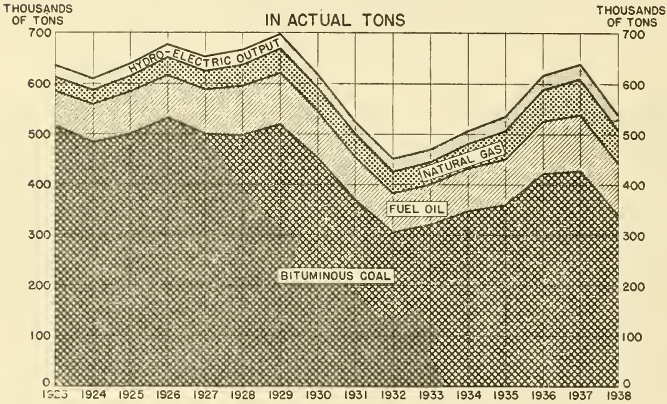
[17] Some of the factors which have contributed to this increasing fuel economy in railroads are: Longer boiler tubes in the locomotives transfer heat more efficiently; improvements in fireboxes permit better draft and better combustion; superheaters raise

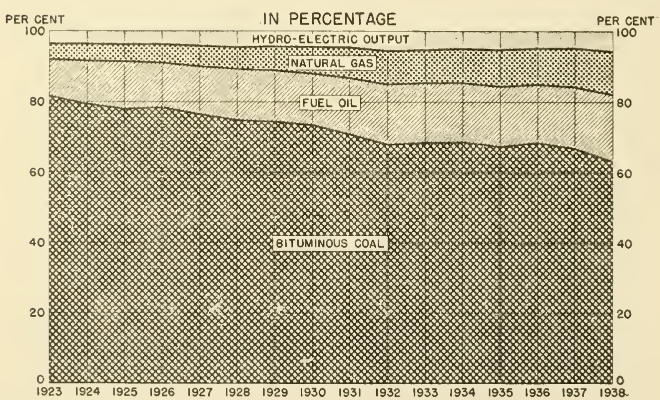
Chart V

CONSUMPTION OF FUELS REDUCED TO BITUMINOUS COAL EQUIVALENT

BITUMINOUS COAL, COAL EQUIVALENT OF FUEL OIL AND NATURAL GAS, AND OUTPUT OF HYDRO-ELECTRIC POWER REDUCED TO COAL EQUIVALENT

UNITED STATES, 1923-1938





Source: Table 5.

TABLE 6.—*Loss of employment in coal by causes, 1923–37*

	Men	Percentage
A. Increased labor productivity (including mechanization, etc.)	78, 140	28. 7
B. Increased efficiency of utilization	33, 950	12. 4
C. Technology of substitute fuels	74, 540	27. 3
Total	186, 640	68. 4
D. Shrinkage of market	86, 040	31 6
Actual shrinkage of employment (1937)	272, 680	100. 0

Source: Hearings before the Temporary National Economic Committee, Part 30, exhibit 2738, table 24.

In public utility electric power plants 3 pounds of coal were required to generate a kilowatt-hour of electricity in 1920; in 1938 only 1.41 pounds were required, a decrease of 53 percent, or a reduction in use of 57,047,000 tons for 1938.

In the manufacture of iron and steel, the number of pounds of coking coal required per ton of pig iron in 1920 was 3,421; by 1938 it was reduced to 2,865—a decrease of 16.3 percent, or a reduction in use of 5,325,551 tons for 1938.[18]

The general tendency toward increased efficiency in fuel consumption by large industrial consumers is shown in chart VI.[19]

In still another way has the substitution of electric energy tended to increase the productivity of labor. As is pointed out in another chapter,[20] the most modern and efficient types of productive equipment are generally those which are electrically operated. If a producer is induced to use a larger amount of electric energy by low rates, it is likely that he will install the most productive types of machinery. On the other hand, if electric energy is derived from steam-generating plants which use coal as their source of power, the increase in productivity in the plant may be offset to some extent by the large amount of labor involved in the production of coal. Where hydroelectric power is used, or where the energy is generated

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the temperature of the steam and give it greater expansive force; steam separators or so-called desaturators reduce the moisture in the steam and permit easier supercharging; special heaters preheat feed water in the locomotive boiler; the reduction in the dead weight of locomotives and cars makes it possible to handle more weight in trains at quicker speeds with the expenditure of less fuel. Hearings before the Temporary National Economic Committee, Part 30, p. 16602.

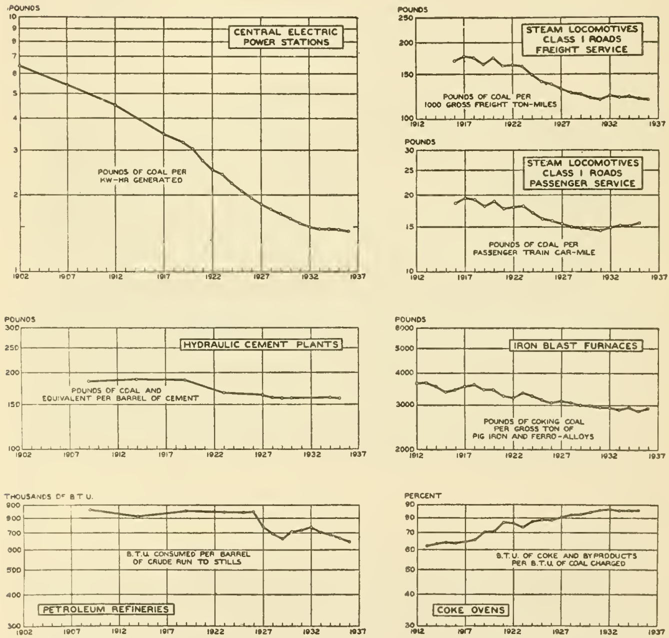
[18] Ibid., p. 17518.

[19] National Research Project, Fuel Efficiency in Cement Manufacture, 1909–35, p. 3.

[20] See pp. 202–208, infra.

Chart VI

PROGRESS OF EFFICIENCY IN THE CONSUMPTION OF FUEL BY LARGE INDUSTRIAL CONSUMERS IN THE UNITED STATES



Source: Works Progress Administration, National Research Project, Fuel Efficiency in Cement Manufacture, 1909–35, p. 3.

by Diesel engines—the importance of which, as a source of electrical energy, is rapidly increasing[21]—the amount of labor involved is so small that it would not offset increased plant productivity.

The effect of all these forces has been an actual displacement of workers from the coal industry. The average number of miners displaced from 1923 to 1937 by the substitution of new fuels and by the increased efficiency of coal has been estimated as follows:[22]

Substitute fuel oil	16, 100
Substitute natural gas	23, 900
All hydro-electric power	34, 540
Increased efficiency of utilization	33, 950
Total	108, 490

An additional estimated 78,140 workers were displaced through mechanization and the increased productivity of labor.

A future possibility in the displacement of labor through the substitution of an almost laborless form of energy is atomic power. A recent article on the possibilities of applying atomic energy to industrial uses states:

> There are many gates to the reservoir of atomic energy, and one of them has been opened * * * A new substance, uranium 235, which releases atomic energy easily, has been isolated; one gram of its mass contains a total energy of about 11,700,000 kilowatt-hours of electricity, of which about one-tenth of 1 percent can be annihilated and released as the equivalent of 11,700 kilowatt-hours of electricity, or about 5,000,000 times more energy than can be obtained from burning an equal weight of coal.[23]

Before atomic power can be used to run the wheels of industry many practical problems must be solved. Principal among them are the scarcity of ores containing uranium compound and the great expense involved in freeing the active component. If the demand for the material becomes great enough, known deposits will be exploited, other sources of supply will no doubt be found, and reductions in price will almost inevitably follow.

Though no one can predict when this new power will emerge from the laboratory ready for industrial use, the possible economic effects of its practical application should be borne in mind in any consideration of economic trends. Any widespread use of atomic power would ruin the coal industry. Practically the only markets remaining to it would be the production of coke for byproducts and the steel industry. Railroads would lose that substantial proportion of their revenue derived today for the transportation of coal, and their savings from the use of atomic power would not compensate for this loss. The oil industry would suffer alike with coal since the motive power of automobiles might well be changed from internal-combustion to steam, with the fuel supply for the life of the car built in at the factory. Atomic power might become the basis for a new method of generating electricity without requiring any apparatus for transforming heat into mechanical, and mechanical into electrical energy, thus eliminating boilers, engines and dynamos.[24]

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[21] Diesel engine installations by 1940 represented over 15,000,000 horsepower, which otherwise would largely have been generated by coal. (Hearings before the Temporary National Economic Committee, Part 30, p. 17189.)
[22] Ibid., p. 17190.
[23] John J. O'Neill, "Enter Atomic Power," Harpers Magazine, vol. 181, June 1940.
[24] Ibid.

Remote as these possibilities may seem at the present time, they would only carry to a logical conclusion tendencies already existent in the field of power and energy development.

MATERIALS

Substitute Materials.

The measurement of changes in labor productivity in terms of a specific type of goods tends to minimize the extent of labor-saving since labor-displacement resulting from the substitution of one material for another is not taken into account. For example, between 1927 and 1937 the production of paper bags increased by approximately $26,000,000, while the production of textile bags declined by $45,000,000.[25] A comparison of changes in output per man-hour in textile bag manufacture with those in paper bag manufacture would not at all reveal the amount of labor displaced in the transition to the newer type of bag since less labor is required to manufacture paper bags than textile bags. In an analysis of this nature it should be borne in mind that the number of man-hours required to produce a quantity of a given type of goods is not necessarily the same, because of substitutions, as the number of man-hours required to produce a quantity of goods necessary in the performance of a given function.

The replacement of one commodity by another is pertinent to this study only if the new item requires less labor per unit to perform a given function than the product replaced. In general, the more important substitutions throughout the history of industrial society have usually been accompanied by considerable reductions of labor required per unit.

When, for example, a natural product is replaced by a chemically produced article, a decrease in unit labor requirements almost invariably takes place. Reductions in labor required occurred in the case of such substitutions as rayon for silk, vanillin for vanilla beans, sodium silicate for dextrin and glue, lacquers for varnish, synthetic for natural camphor, and aspirin for quinine. The production of ammonia, methanol, and acetic acid from chemical raw materials by chemical processes likewise reduced the amount of labor required per unit.[26]

Unit labor requirements are reduced by such substitutions because the amount of labor required in chemical production is relatively small. A comparison between chemical and other industries as to the proportion which wages constitute of the value added by manufacture shows that in the chemical field, labor's share is quite low.[27]

The changes which have taken place in the painting of automobiles are illustrative of the way in which the substitution of a synthetic product reduces the amount of labor required not only in the production of the material but also in its application. Before the first World War automobiles were painted with natural enamels. Many coats were needed and their application required a relatively large

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[25] U. S. Bureau of the Census release, Background 1940 Census, ch. 4, p. 4 (undated).

[26] Through the use of certain well-known types of chemical reactions on a few basic materials, principally coal, natural gas, petroleum, plants, molasses, and wood, a host of products are made synthetically in competition with similar products made from natural materials. Vast indeed is the field of synthetic organic chemicals and dye intermediates in which a few of the approximately 200,000 known carbon compounds serve as the starting materials for scores of such products as medicines, tannins, perfumes, dynamite, drugs, solvents, sweetening agents, rayon, antiseptics, and lacquers.

[27] See appendix E.

labor expenditure and much handling. Since the enamels were very slow in drying, approximately 2 weeks were needed to paint a car. The slowness of the process often tied up production all along the line with a consequent decline of labor productivity in the entire plant. Shortly after the war nitrocellulose lacquers replaced the old enamels. Although about 10 coats were required, the period of drying was greatly reduced so that the entire process was shortened from weeks to hours.

During the early thirties synthetic enamels were introduced, 3 or 4 coats of which achieved the same result as 10 coats of lacquer. Huge tunnels were constructed in which each coat of the synthetic enamel was baked on in about 2 hours, thus eliminating slow air-drying. Now infra-red lamps line the ceiling and walls of the tunnel and reduce the time to about 10 minutes per coat.

Chemically produced articles are by no means the only ones featuring in replacements. Alloy steels are being used increasingly in place of forged steel; they decrease operations and labor expenditure required to perform certain functions. The introduction of camshafts and crankshafts made of alloy cast in place of forged steel has eliminated at least 10 operations formerly done by machine and handwork in one process of automobile manufacture.[28]

Some replacements raise the question of durability. Where durable goods replace a perishable commodity, a decline may occur in the total amount of labor needed to meet a given need over a long-term period. When, for example, electric refrigerators replace manufactured ice, a net decline probably takes place in the amount of labor required over a period of time to keep foods cool. The amount of labor involved in the production, sale, transportation, installation, and occasional repair of a refrigerator over its life-span is undoubtedly less than the amount of labor required for the production, sale, transportation, and installation of an ice-box plus the labor required in the continual production and delivery of the ice.

There is also the complicating factor that the total amount of labor required for the production of any new durable goods, after an initial spurt following its introduction, usually declines as the market for the product becomes increasingly saturated. Perishable goods, on the other hand, are almost immune from this phenomenon of market saturation.[29]

Perhaps a brief analysis of some of the substitutions in the basic labor required for the production of any new durable goods after productivity may be increased due to new materials replacing old. Until the beginning of the last century the basic durable material of

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[28] National Recovery Administration, Research and Planning Division, Preliminary Report on Study of Regularization of Employment and Improvement of Labor Conditions in the Automobile Industry, 1935, appendix B, exhibit 16, p. 15.

A somewhat similar case is the so-called "quick-setting" or high early strength cement. This type of cement is usually interchangeable with ordinary portland cement, except in a few cases, such as the construction of large dams. Its particular advantage is that it requires only about 3 days to set compared with approximately 28 days for ordinary cement. The method of laying down the cement is the same for both types, but a considerable saving of labor occurs in the subsequent processing. Ordinary cement must be kept moist for at least 10 days after it is laid down, compared with 2 days for quick-setting cement, a saving of approximately 90 percent in the labor required in the moistening process. The quality of ordinary cement has been improved to reduce its period of setting. Despite these improvements, quick-setting cement has made considerable inroads on the markets of the regular type.

[29] For an analysis of the problem of market saturation, see T. N. E. C. Monograph No. 1, Price Behavior and Business Policy, by S. Nelson and W. Keim.

our economy was wood. It was the fundamental construction material for implements, tools, presses, water pipes, cylinders, household furnishings, vats, barrels, gearing, pumps, and even machinery such as lathes.[30]

But with all its attributes wood could not stand the competition of metals. By 1917 the plight of the lumber industry had become acute and in a study made at that time the Department of Agriculture found that the annual substitution for wood in all forms amounted to approximately 27,715,000,000 board feet—of which 8,090,000,000 was for wood in the form of lumber—and that the general trend indicated increasing replacement.[31]

There has been no abatement in the replacement of wood, because other materials have been developed which are less expensive and more durable. One authority (Dr. John E. Teeple) has observed that wood—

> has long since ceased to be a necessity either as a fuel or a construction material, for furniture or for charcoal. Its chemical use as a source of methanol, acetic acid, and acetone has already been replaced by synthesis and could be discarded entirely without the least inconvenience to chemical operations. Its use as raw material for making newsprint paper and near-silk garments would present a more serious difficulty, and these industries would be forced to use annual cellulose from plants instead of perennial cellulose from trees.[32]

A unit of wood undoubtedly involves much more labor in fabrication than a unit of metal. Wood is not malleable; it cannot be melted and poured into a desired shape; it is bulky and breakable; it defies complete standardization; and it requires a relatively high degree of skill in fabrication.

Two outstanding results of the substitution of metals for wood are: (1) The amount of labor required to perform a given function has been markedly reduced;[33] and (2) the use of metal has made possible a great expansion in industrial production.

The next possible change in the economy's basic durable goods already looms on the horizon: the substitution of plastics for metals. Plastics are made by the action of acids, formaldehyde, or other chemicals on such materials as vegetable fibers, soybeans, dried blood, or camphor. Some of the natural materials used as a base were formerly regarded as waste. The products consist of these chemically treated, moldable substances, together with coloring matter and fillers of clay, talc, asbestos, or mica.

Various types of plastics, together with their typical uses, are summarized in appendix F. It is sufficient here to note that the uses range from adhesives to watch crystals, from automotive and airplane parts to telephone equipment, and from bearings to transcription records. Despite the extent of their use, the potentialities of plastics have hardly been tapped. In the automotive field, window

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[30] "As raw material, as tool, as machine-tool, as machine, as utensil and utility, as fuel, and as final product, wood was the dominant industrial resource * * *" (Lewis Mumford, Techniques and Civilization, Harcourt Brace, 1934, p. 120.)

[31] U. S. Department of Agriculture Rept. No. 117, "The Substitution of Other Materials for Wood," Studies of the Lumber Industry, Part XI, 1917, by Rolf Thelen.

[32] Williams Haynes, Men, Money, and Molecules, Doubleday Doran, 1936, p. 158.

[33] The relatively large labor expenditure inherent in wood applies not merely to the production process itself but also to maintenance and repair. In railroads, to cite but one instance, the introduction of all-steel box cars and the more general use of all-steel open-top cars; the practical elimination of wood from passenger cars and from a large portion of the freight cars has led to greater efficiency and less frequent repairs. (Hearings before the T. N. E. C., Part 30, p. 16612.)

frames, glove compartment doors, and headlamp shells have been the major contributions to date.[34]

One of the important potentialities of this new material is the development of plastic fenders and molded plastic bodies for automobiles, and of plastic airplane fuselages and wings. As early as 1933 Henry Ford said, "Bodies * * * can be made from cellulose of cornstalks, with a woven-wire reinforcement inside and steel reinforcement at the doors, and will be lighter, stronger, and quieter than metal bodies." [35] The attainment of this goal has been blocked up to the present time by limitations on the size of moldings. That this major difficulty is nearing a solution is indicated in a recent article by a technician in the field, Gordon M. Kline, of the National Bureau of Standards, who says, "Some progress has been made toward the development of a technique of molding which offers promise of eliminating the major obstacles of limitations on press sizes and capacities and mold expense." [36]

The significance of this possible substitution of plastics for metals is that plastics require much less labor than metals in their production. In fact, the process of plastic manufacture is almost completely automatic and as the industry expands, unit labor requirements may be expected to fall to even lower levels.[37]

This saving of unit labor expenditures would appear even larger if the productive process were carried back to the extraction of raw materials.[38] Most plastics are derived either from vegetable matter, chiefly cellulose; from animal matter, chiefly sour milk; from mineral matter, chiefly phenol; and from the air itself, chiefly nitrogen in the form of synthetic urea. These raw materials obviously involve less labor per unit than the production of metals, for essential to metal manufacture are such labor-consuming functions as the extraction and transportation of coal and ore.

Prophecy of future technological developments is not within the realm of this study. The potential widespread use of plastics is

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[34] Among potential applications of plastic moldings in automotive engines and chassis are the following parts: tappet covers, rocker covers, wheelcases, water-pump rotor, water-pump bushings, oil pumps, rockers, cam wheels, chain wheels, fan blades, camshaft bearings, thrust washers, steering-joint bearings, gear-box and rear-axle covers, cable conduits, filler caps, brake cross-shaft bearings, and spring interleaves. (See Journal of the Society of Automotive Engineers, May 1940, "Plastics and Their Uses in the Automotive Industry," by Gordon M. Kline.)

[35] Time, Feb. 13, 1933, p. 13. Plastics may also come to replace textiles in certain fields. "These new developments (in insulation) may over a period of time have an important effect on the production of cotton yarns and fabrics. Great quantities of cotton yarns are used for insulation purposes, and if * * * plastic comes up to expectations in this field, its increased use may replace a considerable part of the business now going to cotton spinners. The application of * * * plastic to ordinary fabric covers and lace fabrics should also be of interest to the cotton trade." (American Wool and Cotton Reporter, Aug. 29, 1940, p. 18.)

[36] (Kline, loc. cit.) An Associated Press dispatch of June 25, 1940, reported the formation of a new military aircraft concern. The company, to be known as the Twentieth Century Aircraft, Inc., will produce "pursuit ships with the fuselage and wings of plastic speedmold construction, with veneer sheeting impregnated with synthetic plastic material." The fighter planes are expected to have a speed of 340 miles an hour. (The Evening Star, Washington, June 25, 1940.)

[37] The first stage is the production of the resin—a chemical process performed in digesters or kettles. Next, the resin is mixed with the filler by means of rolls and grinders. It is then packaged as a powder in large drums. The fourth stage consists in molding the material into desired shapes; the material is simply fed into a hopper, and, by means of recently developed machinery, automatically molded. In the final stage of finishing and polishing, the highly efficient equipment already developed to perform those functions on other materials is merely adapted to plastics.

[38] Says the Department of Agriculture: "It appears that the recent rapid technical advances in the arts of making and using plastic compositions are likely to lead to continued growth of the plastics industry. The quantity of agricultural products required in such growth, while not inconsiderable, is still relatively small compared with the total supply of the products." (U. S. Department of Agriculture, The Agricultural Situation, September 1940, p. 22.)

merely another link in the chain of replacement inherent in technology and is pertinent to this analysis because it involves the substitution of a material requiring less labor than the product replaced.

As metals replaced wood, the accompanying expansion in industrial output undoubtedly more than absorbed the labor displaced by the substitution. Whether there will occur a similar expansion in industrial output upon the possible substitution of plastics for metals, an expansion which would have to be tremendous to absorb the displaced labor, is a matter of conjecture.

Improved Materials.

Improvements are constantly being made in existent materials which also reduce unit labor requirements. One type of improvement is greater durability which reduces the number of units of an article required over a period of time and the amount of labor required in production. Breakdowns also occur less frequently and the amount of labor involved in maintenance and repair is lowered. For example, in the last 20 years the life of wooden railroad ties has been extended by pre-treatment to about 21 years, compared with 8 years for the untreated tie. Since there are about 3,000 ties to every mile of track, the amount of labor saved in both their production and installation is tremendous. Similarly, the use of rust-resisting steel on railroad cars has eliminated much servicing and painting and has also prolonged the life of the car.[39] Another widely cited instance of increased durability is the automobile tire. Between 1920 and 1937 the life of the average automobile tire more than doubled, rising from about one and one-quarter years to nearly 3 years.[40]

The constant improvement of cables and wires in the electric power and light industry likewise has reduced the amount of maintenance and repair labor required. Overhead transmission lines have been made more durable with improved insulators, and cables for underground high voltage transmission have been materially improved through the introduction of new insulating mediums. In the distribution of power, new and improved types of cables and wires have also reduced materially the possibility of breakage or interruption.[41]

Innumerable instances of both substitutions and improvements in quality can be found in almost any segment of the industrial world. All illustrate the ways in which substitute materials and improved materials may bring about reductions in unit labor requirements: (1) By replacing a product with a new article which in its production requires per unit a smaller amount of labor and (2) by increasing the durability of an existent material, so that over a period of years fewer units are required and the amount of maintenance and repair labor is reduced. The examples also indicate the vast extent of the terrain to be covered in an analysis of the ways in which technology operates to increase the productivity of labor.

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[39] Hearings before the Temporary National Economic Committee, Part 30, p. 16612.

[40] U. S. Bureau of Foreign and Domestic Commerce, Rubber News Letter, vol. 13, No. 19, October 15, 1939.

[41] National Resources Committee, Technological Trends and National Policy, June 1937, pp. 279, 280, 286.

The Bureau of Labor Statistics has observed that one of the principal factors responsible for increased labor productivity in this industry is the improvement in the wearing qualities of electrical equipment, with corresponding reductions in maintenance labor. (U. S. Bureau of Labor Statistics, "Labor Productivity and Displacement in the Electric Light and Power Industry," Monthly Labor Review, August 1932, pp. 249–259.)

PROCESSES

New processes which reduce unit labor requirements are constantly being introduced. These may be classified as (1) mechanical, which achieve changes in products without chemical reaction or direct use of electrical energy,[42] and (2) nonmechanical, which bring about changes either by chemical reaction or direct use of electrical energy or through electro-chemistry.

Mechanical (Including Multiple-Function Machinery).

An entirely new mechanical process or a new type of multiple-function machinery usually represents labor-saving in its most spectacular form. Perhaps the most outstanding example of this type of technique is the replacement of the old hand mill by the continuous strip mill in iron and steel manufacture. Before the introduction of the continuous strip mill it was necessary to cool billets or slabs upon leaving the open hearth, reheat them, and then to push and pull them by manual force through slowly operating steam-powered rollers until the desired steel shapes were formed.

In a typical continuous strip mill the hot slab first passes through a scale breaker which removes the scales due to oxidation. Traveling along on rolls the slab then passes through a number of "roughing" mills in succession, each over 20 feet in height. Top and bottom rollers weigh approximately 100,000 pounds apiece and the center rollers 22,000 pounds apiece. At this stage the steel has again accumulated scale, so it passes through a second scale breaker. Beyond the second scale breaker, rolls carry the slab—by this time elongated into a strip—into a series of six finishing stands, each of which has two sets of rollers arranged horizontally. These finishing stands successively reduce so effectively the thickness of the steel that a single strip may be going through the rollers of all six stands simultaneously. Each stand operates slightly faster than the one ahead, and the greater the degree of reduction to be accomplished, the faster each successive stand operates.

The six stands in a typical mill have a combined weight of approximately 5,000,000 pounds and are so large that, were the rollers removed, an automobile could be driven through the middle. The entire continuous strip process is electrically controlled and operated by a switchboard from a pulpit. As the steel comes out from the last finishing stand in a long strip reduced to the desired thickness, hot flying shears, synchronized with the last finishing stand, cut the strip to the desired lengths.

The labor-saving effected by this new process has been tremendous. It is estimated that 126 men in the automatic steel mills can produce the same tonnage as 4,512 men in hand mills, a 97 percent reduction in man-hours. Actually, human labor is practically eliminated in the rolling process with electric power substituted in its place.[43]

Another relatively new metallurgical process is the pouring of molten materials into molds which requires little labor expenditure compared with methods involving beating, hammering, pounding,

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[42] The "direct use of electrical energy" does not include electrical energy as a source of power or heat.

[43] Hearings before the Temporary National Economic Committee, Part 30, p. 16459. For further discussion of increased labor productivity in iron and steel, se epp. 235-240, infra.

pressing, etc. The electrical equipment industry has recently applied this process to the manufacture of magnets, and thus maintains the same output at a reduction of approximately 75 percent in labor expenditure. Magnets are now poured into molds instead of being formed, eliminating such operations as cutting, forming, hardening (now accomplished by the use of cobalt), aging, gap grinding, shoeing, single magnetizing, and measuring the steel. Incidentally, the magnet thus produced is of a better grade than that manufactured under the old method.[44]

Of fundamental importance to the automobile and related industries is the one piece stamping process. Its use in only one segment of the automobile, the so-called underbody, has eliminated 18 different parts which no longer have to be built and assembled. Stamping is an excellent illustration of the transition from process to multiple-function machinery. In many automobile plants where previously four or five stamping presses were necessary, a multiple press has been introduced. Dies are now constructed so that a whole series of stamping operations may be done on one machine.[45]

A familiar though striking illustration of a new process is the dial telephone. As a result of its use, the American Telephone and Telegraph Company has ceased hiring approximately 25,000 girls a year and instead is displacing many whom it has employed for years.[46] Improvements in the dial process frequently result in an almost complete elimination of operators. The only functions of operators in a modern dial office are (1) to run the cordless B board, on which terminal calls from manual offices come in, and (2) to handle ticket calls, those outside the contiguous or free area. Formerly ticket calls had to be put through by an operator, but with zone dialing a customer now dials practically any number within a metropolitan area. Zone dialing transfers the prospect of completely automatic phone service from a remote possibility to a probability.

Nonmechanical.

In some cases nonmechanical processes are replaced by those of greater efficiency; in others, mechanical processes are replaced by nonmechanical methods. Just as chemically produced materials reduce unit labor requirements by replacing natural commodities, the replacement of labor-consuming mechanical processes by automatic chemical methods also reduces the amount of labor required.

An outstanding instance of this type of technological advance is the so-called selective flotation process of concentration in the nonferrous metals industries and related fields.[47] The conversion of ores of non-ferrous metal content into pigs or slabs of the refined metal involves three separate operations: Concentration, smelting, and refining. The concentration operation was formerly performed by the interaction of gravity and direct oscillation. Through the action of jigs, tables, vanners, and rolls the metal content was separated from

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[44] Hearings before the Temporary National Economic Committee, Part 30, p. 17422.

[45] Ibid., p. 16380.

[46] The extent of the labor reduction effected by the dial telephone is illustrated by the Boston metropolitan area, which now employs only 3,500 to 4,000 operators. Based on the number of stations and messages handled by an operator in 1925, at least 12,000 operators would now be required to operate this system manually, a job opportunity loss of 75 percent. Hearings before the Temporary National Economic Committee, Part 30, p. 16672.

[47] For further discussion of increased labor productivity in non-ferrous metals, see pp. 244–247, infra.

the ore. The efficiency of this method in the recovery of mineral content was comparatively low.

The process which changed completely this rather crude method of concentration was introduced in this country in 1911, has had a phenomenal growth and predominates in the nonferrous metals industries today. The selective flotation process utilizes chemical attraction to separate desired mineral particles from waste. Chemicals are combined with a mixture of finely ground ore and water, then air is forced in and the mineral particles stick to the air bubbles and float to the top, there to be collected, while the waste remains at the bottom.

This process has tended to reduce unit labor requirements, not only in the concentration stage but also in the ensuing smelting and refining operations through raising the mineral content of the feed. It has also stimulated the development of improved grinding processes and of the reverberatory furnace, which replaced the blast furnace, increasing labor productivity in the smelting operation.

A similar process for ferrous metals has been developed, the magnetic separation of ores. Here magnetic force rather than chemical attraction performs the function of separation. This method has replaced the crude method of selection in ferrous metals just as selective flotation has in nonferrous metals, with similar savings in unit labor requirements.[48]

Labor-saving has also resulted from process changes in the rubber tire industry. By the use of organic accelerators the time required for curing rubber tires has been reduced from one-half to two-thirds with, incidentally, only small attendant capital outlays.[49]

An electrical process has replaced a mechanical process in the substitution of welding for riveting. Rivets and their installation involve much more labor than welding, and when the welding process becomes automatic—that is, when spot or flash welding is done in a so-called welding machine—the disparity between the two processes in labor requirements becomes enormous.[50]

A recent advance in paper making—that of securing bleached pulp from southern pine by the sulphate process—illustrates the indirect way in which a change in processing may result in increased labor productivity. The principal product of plants in the South using the sulphate process formerly was an unbleached pulp, but there is a growing tendency, made possible by advances in chemical processes, to manufacture and sell bleached pulp. This greater diversity of products enlarges their market and makes possible a more sustained rate of operation, which results in greater efficiency and lower unit labor requirements.

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[48] By passing iron ore beside the magnetic separators, the ferrous content is immediately attracted and thus separated from the main body of the ore. Also, in the cleaning of metal scrap, those elements of the scrap with ferrous content are removed from the remainder of the material. The amount of labor required has been greatly reduced by the utilization of this electrical process.

[49] Hearings before the Temporary National Economic Committee, Part 30, p. 17226.

[50] In automobiles, for example, "the assembling of the steel panel that comprises the complete body is accomplished by placing panels into a so-called welding machine, which is really a jig with locating pins against which to set the panels, so that in the true positions they are automatically spot or flash welded. * * * Welding of the back and quarter panels requires one welding machine with two men to operate, and a helper for finishing." (National Recovery Administration, Research and Planning Division, Preliminary Report on Study of Regularization of Employment and Improvement of Labor Conditions in the Automobile Industry, 1935, Appendix B, Exhibit 16, p. 4.

Labor productivity and general efficiency will undoubtedly continue to be increased materially by new and improved chemical and electrical processes. Industry has only begun to utilize their immense potentialities while major mechanical improvements are becoming increasingly difficult because of the high level of efficiency already attained by many mechanical techniques.

INDIVIDUAL, SINGLE-FUNCTION MACHINERY

Improvements in individual single-function machinery may be grouped according to the three ways in which they reduce unit labor requirements: (1) Elimination of one or more hand operations; (2) increasing the speed of the machine; and (3) enlargment of capacity without a corresponding increase in labor requirements for feeding and attending.[51]

The principal advantage of this classification is that it does not become hopelessly detailed due to the infinite number of variations in structural characteristics of most types of machinery. Certain improvements in individual machines reduce unit labor requirements in all three ways, but this does not invalidate the classification. The new wristpin inspection machine, for example, eliminates hand operations, increases the speed of operation, and enlarges capacity. A discernible difference exists, however, between those types of equipment designed primarily to eliminate hand operations and those designed to increase either the speed or the capacity of the equipment.

Many improvements in textile manufacture, for example, have had as their primary objective the increase in speed of operation, but in certain cases capacity has also been enlarged. Consequently, in grouping labor-saving machines, the primary way in which they save labor will be the basis of classification. It should be borne in mind that if a particular technique increases labor productivity in several ways, its difficulty of classification in no way lessens its effect upon labor.

Elimination of operations.

The installation of new types of machinery or the improvement of existing equipment is constantly eliminating hand operations in the industrial world. Seldom spectacular, these changes are primary causes of increased labor productivity.

The automobile industry presents some interesting examples of the introduction of equipment which has eliminated a considerable amount of labor expenditure.[52] One such apparatus is a completely automatic inspection machine, which, with a photo-electric eye, grades wristpins as to size in thousandths of an inch and as to shape and smoothness of surface. The machine eliminates from 10 to 20 inspection men formerly required to grade the same number of pins.[53] It proved so satisfactory on wristpin inspection that a similar machine was designed for camshaft inspection and now 4 men perform the

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[51] Harry Jerome, Mechanization in Industry, National Bureau of Economic Research, New York, 1934, p. 42. This classification of labor-saving machinery is somewhat similar to Professor Jerome's, except that he restricts the third type to enlargements of capacity merely through greater physical size. Recent technological developments indicate that capacity of certain types of equipment may be increased without either an increase in physical size or a corresponding increase in labor requirements for feeding and attention.

[52] See pp. 256–260, infra, for further discussion.

[53] National Recovery Administration, Research and Planning Division, Preliminary Report on Study of Regularization of Employment and Improvement of Labor Conditions in the Automobile Industry, appendix B, exhibit 16, p. 11.

work formerly done by 18. Another robot, designed along similar lines to inspect crankshafts weighing 75 pounds each, enables 2 men to perform work formerly done by 90.[54]

One automobile factory formerly placed ring inserts for valve seats in cylinder blocks by hand. Machines now insert all valve seats in the block at once. Three men operate the machine with one mechanic as repairman, with a resultant labor saving of over 60 percent in this operation.[55]

The automatic tube molding process in the rubber tire industry is another instance of the elimination of hand operations. By means of this equipment the manufacturing costs of one rubber company were reduced at least 40 percent, and incidentally the quality of the product was improved. Similarly, new types of equipment eliminated entirely the use of press cloths and effected a reduction in labor requirements of over 60 percent in the extraction of oil from linseed. One large company was able to effect savings of 4 cents per bushel of linseed crushed by this process.[56]

The elimination of operations is strikingly illustrated by the almost uncanny devices used to regulate and control the movements of railroad trains. Chief among the innovations in this field are the automatic block signal systems, automatic train control, interlocking plant and remote control, which make it possible to manipulate all main line track switches and signals in a given district or entire division by a centralized traffic control board.[57]

A similar development in the field of electric power transmission is the replacement of manually operated substations by automatic substations. During the 1920's the installation of improved relay and protection equipment made possible an extremely rapid growth in unattended automatic substations. "Control relays are used to start the machines as load conditions require, to connect the unit to the line, and to shut it down when no longer needed. Protective relays furnish the protection desired against abnormal conditions such as short circuits, etc." Between 1920 and 1930 the number of unattended substations in five representative systems increased by 320 percent, while the number of attended substations rose by only 41 percent. By 1931 in one large system 72 percent of all substations were entirely automatic.

The electric light and power industry was also in the vanguard in the installation of automatic stoking and of powdered fuel equipment. By 1928 over 97 percent of the coal burned for the production of electric power was fired mechanically.[58]

These instances illustrate the many fields in which operation-eliminating equipment has been developed, thus destroying job opportunities.

Increasing of Speed.

The textile industries afford some of the most outstanding examples of speed of productive equipment being increased without a corresponding advance in the amount of labor required.[59] Each depart-

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[54] Ibid.
[55] National Recovery Administration, op cit., p. 14.
[56] Recent Economic Changes in the United States, vol. I, first edition, 1929, pp. 14–15.
[57] Hearings before the Temporary National Economic Committee, Part 30, p. —.
[58] U. S. Bureau of Labor Statistics. Monthly Labor Review, August 1932, "Labor Productivity and Displacement in the Electric Light and Power Industry," p. 258. See also pp. 266–269, infra, for further discussion.
[59] For further discussion see pp. 272–275, infra.

ment in the cotton-textile industry has shown a marked increase in the speed of operation during the last 30 years. In the spinning department several makes of long-draft devices permit the use of a roving about twice as coarse as that used a few decades ago. "The coarser roving can be made on a large-size bobbin, which decreases the frequency of replenishing the supply packages on the spinning frame." The speed of operation is thus obviously increased. A similar result has been achieved in the spooling process through the use of an "automatic machine on which all the knots are tied by the machine itself," and of "a high-speed tube or cone winder * * * designed to permit a reduction in the time required to tie a knot. Through the use of the first type of equipment the yarn is removed from the bobbin at a rate of approximately 1,200 yards per minute as compared with an average speed of about 200 yards per minute in 1910." High-speed warpers are in use which operate at 350 to 900 yards per minute, depending upon the type and size of the yarn, compared with an average speed of only 50 yards per minute in 1910. In addition, these warpers have magazine creels which permit continuous operation, as well as tension devices which reduce end breakage.[60]

The manufacture of cigarettes affords two interesting examples of the way in which labor productivity may be raised by increasing the speed of operation.[61] The first is a new type of cutting machine which makes use of several knives set in a rotating arbor like the blades of a fan. These knife blades are automatically cleaned and sharpened as the machine operates, eliminating the necessity of stopping the machine frequently to change blades. The old type of machine, consisting of a reciprocating knife which operated in guillotine fashion, had to be stopped often for resharpening.

Similarly, the cigarette-making machine has been improved. Formerly machines operated at the rate of about 700 to 800 cigarettes per minute; the newer type of apparatus throws out cigarettes at a speed of 1,200 to 1,500 per minute.[62]

In metallurgy the introduction of the sand cast method in centrifugal cast pipe manufacture has not only resulted in a marked reduction in equipment but in great savings of time required in the productive process.[63]

All through the processes involved in the manufacture of automobiles and related equipment, changes have steadily taken place which have made it possible in numerous instances for a worker to operate a larger number of machines or to run machines at higher rates of speed.[64]

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[60] Boris Stern, "Mechanical Changes in the Cotton Textile Industry, 1910 to 1936," U. S. Bureau of Labor Statistics, Monthly Labor Review, August 1937, pp. 327–332.
The weaving department has seen changes of a like nature. From 1910 to 1936 the actual speed of an automatic 40-inch loom was increased from about 160 picks per minute to about 192. "This increase of approximately 20 percent is more than realized in the loom output, as the weaving efficiency of looms in 1936 averages from 2 to 5 percent greater than could have been obtained in 1910 on the same fabric." (Ibid, pp. 334–335.)

[61] For further discussion see pp. 262–264, infra.

[62] Chemical and Metallurgical Engineering, "Cigarette Industry Rules Out Rule of Thumb," vol. 43, No. 3, March 1936, pp. 128–131.

[63] Recent Economic Changes, pp. 14–15.

[64] A machine typical of many new types of apparatus in manufacturing is the so-called special piston machine used to finish-turn pistons in automobile manufacture. Eight spindles with a turning speed of 1,700 feet per minute revolve about the center axis of the machine. As the spindle containing pistons moves to position in front of an operator, the piston stops turning and the top fixture backs away from the piece. The operator removes the completed piston and places an unfinished one in its place. One man oper-

Enlargement of Capacity.

An illustration of the enlargement of capacity is the growth in the size of rotary kilns in portland cement plants.[65] Between 1900 and 1935 the average length of rotary kilns increased from 70 to 146 feet. In the decade, 1925–35, alone, the increase amounted to 23 feet. Today there are rotary kilns over 400 feet long in operation. Between 1902 and 1935 the estimated annual capacity per kiln rose from 34,000 barrels to 299,000 barrels. The average kiln in 1935 could produce about 60 percent more clinker per yard than a kiln in 1920 and over twice as much as a typical kiln in 1910, and the larger units have not required a correspondingly larger labor force.[66]

In railway shops where labor is engaged in maintaining and building rolling stock, technological innovations have resulted in material enlargements of capacity. A case in point is the multiple planer by which it is now possible to dress 15 or 20 locomotive side rods at one operation. Twenty years ago it was possible to machine only one side rod at a time. This same principle has been applied to drill presses, tapping machines, and treading machines, and the capacity of each has been greatly enlarged.[67]

Enlargement of capacity has been of considerable importance in the textile industry. For example, it has been possible to wind a larger quantity of yarn by increasing the size of section beams in warping equipment.[68]

In industrial-type gasoline locomotives, the average size of individual units sold in 1932–36 was 11.4 tons compared with 7.4 tons in 1924–27. The average dipper capacity of power shovels sold to mining industries by a representative group of companies in 1932–36 was 3.28 cubic yards compared with an average capacity of 1.73 cubic yards in 1920–23.[69]

The instances cited of the ways in which changes in individual single-function machinery can increase the productivity of labor are by no means inclusive. They are indicative of the variety of forms labor-saving mechanical changes take.

A significant feature common to many of these innovations is their ease of application. Few of them represent revolutionary changes in production techniques. They are more in the nature of improvements and refinements which today are constantly taking place throughout the industrial world. In the words of the Assistant Commissioner of the Work Projects Administration:

> Revolutionary changes which result in the direct displacements of workers are by no means a thing of the past. * * * Today, however, such changes rarely occur. The typical changes in industrial processes at the present time are the day-to-day improvements of all existing equipment. They are usually not spectacular and many of them require relatively small capital outlays.[70]

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ates this machine, while heretofore one man was required to start and stop the machine as well as to set pieces in the jig. Compared with the speed of the newer apparatus of 1,700 feet per minute, the cutting speed of the old machine was only 600 feet per minute. The operator of the new machine works continuously in removing and replacing work, and there is a finished piston turned out in less than 10 seconds, reducing materially the time from the old type of machine. (National Recovery Administration, op. cit., exhibit 16, p. 13.)

[65] For further discussion, see pp. 250–253, infra.

[66] Work Projects Administration, National Research Project, Mechanization in the Cement Industry, 1939, p. 354.

[67] Hearings before the Temporary National Economic Committee, Part 30, p. 16611.

[68] Boris Stern, "Mechanical Changes in the Cotton-Textile Industry, 1910 to 1936," U. S. Bureau of Labor Statistics, Monthly Labor Review, August 1937, p. 320.

[69] Works Progress Administration, National Research Project, Effects of Current and Prospective Technological Developments Upon Capital Formation, by David Weintraub, 1939, p. 3, footnote 4.

[70] Hearings before the Temporary National Economic Committee, part 30, p. 17225.

MANAGEMENT METHODS

The displacement of rule-of-thumb by scientific methods in management has likewise increased labor productivity. Innovations in management are of two general types: Those which relate to (1) the human factor and (2) the material conditions of manufacture.[71]

One of the problems in determining the effect on labor productivity of a given innovation relating to the human factor is the difficulty of finding instances in which the effect of only one innovation has been tested. For example, Taylor's classic example of increasing productivity in the handling of pig iron from 12½ to 47½ tons per day per worker illustrates several fundamentals of scientific management: (1) Selection and training of workers, (2) rest pauses, (3) incentive remuneration and (4) study of the science of handling pig iron.[72] Yet one constantly finds citations ascribing the entire increased productivity in this case either to scientific selection or to resting.[73] Accordingly, in selecting the following examples the attempt has been made to use only those which illustrate the effect of a given technique. The variety of management techniques which have increased the efficiency and productivity of labor is so great that only a few types are discussed. This procedure can only serve to indicate the potentialities of management innovations and their various combinations in increasing labor productivity.

Scientific Management and the Human Factor.

Selection and training of workers.—The selection of workers according to ability to perform a specific type of work is usually the starting point for every attempt at scientific management. Many types of examinations to determine an applicant's fitness have been devised ranging all the way from intelligence quotient tests to attempts to ascertain the applicant's attitude toward unionism. While the mere use of some type of selective system does not result in increased productivity, where a real relationship exists between the type of selective test given and the work to be performed output per worker has risen. In the above example of pig iron handling, it would be difficult to say with certainty what proportion of the increased productivity was due to scientific selection. Though it was found that only one out of eight men was physically capable of handling 47½ tons a day, their selection was followed by training in the scientific handling of pig iron. Selection was important but not the sole cause of increased productivity.

Some instances where training of workers appears to be the motivating factor in increased productivity are cited by Burtt. Five girls who were inefficient in packing chocolates were given special training by an expert and improved their output by 27 percent. Two groups of novices were started in this work about the same time, the one group receiving training for 6 weeks. At the end of the period the untrained group required about 25 percent more time to perform the

[71] This classification of management methods is modeled in general after that advanced by the International Labour Office in its publication The Social Aspects of Rationalisation, Geneva, 1931, pp. 12–59.

[72] Frederick W. Taylor, The Principles of Scientific Management, Harper & Bros., New York, 1929, pp. 40–64.

[73] For example, International Labour Office, op. cit., p. 12; Journal of the Society for the Advancement of Management, vol. 4, 1939, p. 43; Harold E. Burtt, Psychology and Industrial Efficiency, D. Appleton & Co., 1929, p. 174.

same operations as the trained group. Similarly, novices in polishing silverware reduced their time per spoon a little more than 61 percent after only 1 day's training. Even workers with 9 years' experience reduced their working time per spoon from 23.2 to 39.5 percent.[74]

Working methods.—Working methods may be changed to increase productivity through: (1) The analysis and division of an individual work process into component motions, (2) the extension of this principle to a group of workers, i. e. chain work, and (3) the granting of rest pauses to eliminate declines in output because of fatigue.

Examples of the effectiveness of motion studies in eliminating excess movements and increasing output are legion, but one or two will suffice to indicate their potentialities. Burtt reports that—

> In a candy factory the process of dipping involved three changes of direction and stopping the hand three times. A new method was devised which made the motion rhythmical and circular although the path covered was somewhat longer. The result was an increase of 27 percent in output.[75]

Economy of motion in applying gummed stickers to packages (plus the simple expedient of having the sticker manufacturer powder them slightly so they did not stick together) has increased output 30 to 50 percent on this particular operation for packagers of confectionery and hosiery and other large users of gummed labels.[76]

Another device, related to rhythm and motion studies, is the use of recorded music, amplified throughout the plant, to induce greater output both by developing greater rhythm and decreasing the boredom of work. In a recent British study it was found that during the time music was played the increase in output varied from 6.2 to 11.3 percent, while the total daily output increased by 2.6 to 6.0 percent. The greatest increase in output was obtained when music was played for 75 minutes about the middle of the work-spell, but the most popular arrangement was the introduction of music during alternate half-hours throughout the work-spell.[77]

One significant application of the chain work technique is the straight-line system of production in the cotton garment industry. Introduced in 1932, it replaced the system in existence since the beginning of factory manufacture in which the bundle, containing scores of layers of cloth cut according to pattern in one operation, was the unit of work. Under the bundle system each worker performed certain operations on all garments in the bundle, which was then turned over to others for subsequent operations until all garments were completed. Under the straight-line system the machines are arranged in the order of operations and as each worker completes her operation on an individual garment or part of a garment she places it within reach of the next operator. This eliminates the carrying of bundles from one end of the shop to the other and the lifting of tons of garments by the operators throughout the course of a day. Since the straight-line

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[74] Burtt, op. cit., pp. 63–64.

[75] Ibid., p. 123.

[76] C. A. Barnes, "Motion Economy on Labeling Operations," Factory Management and Maintenance, vol. 97, No. 12, December 1939, pp. 59–60.

[77] "Different types of music were found to have slightly different effects on output. The average difference was 5.6 percent, but in individual cases it approximated to 10 percent. Although most of the workers responded to the music by an increased output, which in some cases was very marked, there were isolated instances in which the music seemed to have little or no effect on production. The effect in general seemed to be directly related to the amount of boredom experienced by the different individuals." (Medical Research Council, Industrial Health Research Board, Fatigue and Boredom in Repetitive Work, Report No. 77, by S. Wyatt and J. N. Langdon, H. M. Stationery Office, London, 1937, p. 73.)

system aims at the minutest possible subdivision of operations, the operators develop great speed because of the small number of work elements.[78]

Lack of sufficient records makes it difficult to evaluate the effects of the straight-line system on productivity. One engineering firm licensed to install the system claims that a certain garment company increased production 50 percent, cut manufacturing costs 25 percent, reduced clerical work 33½ percent, and inspection costs 60 percent, saved 25 percent of the floor space, and vastly reduced inventory of goods in process. Since it is not known precisely how efficient or inefficient the plant was prior to the use of the straight-line system, these percentages cannot be taken at their face value. In one plant included in the Bureau of Labor Statistics study, however, when the entire assembly department was put on the line a reduction of 34.2 percent in time required under the bundle system took place.[79]

Rest periods are a third expedient of increasing productivity simply by changes in working methods. Burtt reports some experiments with steel riveters whose average production was 600 rivets a day. When they were given a 2 minutes' rest after every 10 rivets, thus spending over 5 hours of the 10-hour day in rest, their production went up to 1,600 rivets.[80] Numerous instances in which rest pauses have contributed to productivity could be cited. The following table gives concisely the effects of various types of rest pauses in a number of simple tasks.

Effect of rest pauses on output for women[1]

Nature of job	Type of pause	Percent of change in output	
Labeling	10 minutes in a. m.	13	Average: 6.2 after some months.
Pressing cardboards	do	5	
Tying small packages	do	8	
Closing shoes	do	11	
Assembling bicycle chains	5 minutes per hour	13	
Folding handkerchiefs	7 minutes in a. m.	4	
Calendering	do	4	
Ironing	do	0	
Hemstitching	do	−3	
Folding handkerchiefs	10 minutes in a. m.	2	Average: 2.8 immediate effect.
Ironing	do	2	
Stamping discs	10 minutes each spell	1	
Polishing spoons	5 minutes per hour	4	
Light work	7 minutes each spell	6	

[1] H. M. and M. D. Vernon, "Five-hour Spells for Women with Reference to Rest Pauses," Industrial Fatigue Research Board, Report No. 47, H. M. Stationery Office, London, 1928, p. 16.

Reduction of hours.—Output per man-hour and even total output have frequently been increased by a reduction in the number of hours worked per day. An increase in hourly performance naturally follows such reductions since monotony, fatigue, and exhaustion not only slow up the workers' productivity but also cause considerable loss due to breakage of machinery or tools.

However, there undoubtedly exists a point of diminishing returns for successive reductions in working time. It is quite likely, for example, that a reduction from an 8- to a 6-hour day would have

[78] U. S. Bureau of Labor Statistics, Bulletin No. 662, Productivity of Labor in the Cotton Garment Industry, by N. I. Stone, Alfred Cahen, and Saul Nelson, 1938, pp. 38–39.
[79] Ibid., pp. 50–51.
[80] Burtt, op cit., p. 174.

less effect in decreasing fatigue and stimulating productivity than a reduction from a 10- to an 8-hour day. Also, the effects of reductions in hours are by no means immediate; in some cases improvement in output comes only after several months have elapsed on the new schedule.

A specific example of the productivity-increasing effects of a shorter working day is afforded by the iron and steel industry. The United States Bureau of Labor Statistics made this observation in its analysis of the change from the 10- and 12-hour day to the 8-hour day in the steel industry:

> Before this change took place it was confidently expected by many that there would be a considerable increase in labor cost because of the increase in the number of men required to operate the furnace. * * *
>
> Theoretically, the substitution of the 8-hour day for the 12-hour day would have no effect on productivity; that is, each position requiring two men at 12 hours each would require three men at 8 hours each and the output per man-hour of labor would remain the same. In actual practice, of course, it would be expected that the output per man-hour would be somewhat higher in the latter case, for it is evident that a man can work at higher speed for 8 hours than he can for 12 hours. But the actual results in the blast-furnace industry following 1923 far exceeded anything that might have been expected. There are numerous cases of plants in which, within a year after the change was made, the total labor force was back again at same number of men that had been employed under the 12-hour system.[81]

The effect of shorter hours on output is shown below for three types of work.

Output in munitions factories[1]

Work	Average weekly hours	Relative output per hour	Relative total daily output
56 men sizing fuze bodies	52.2	100	100
	56.5	122	106
	51.2	139	122
80 women turning fuze bodies	66.2	100	100
	54.8	134	111
	45.6	158	109
40 women milling a screw thread	64.9	100	100
	54.8	121	102
	48.1	133	99

[1] Burtt, op. cit., p. 167.

Incentive systems of remuneration.—Workers are frequently induced to take an interest in increasing output through payments based on piece rates or a bonus in addition to the normal wage. The bonus may be given for quality or quantity of goods produced, speed and regularity of work, savings effected in raw materials, power, fuel, etc. In certain cases, instead of receiving a bonus for increased output, the worker is forced to increase his output so that his net income may reach a normal figure because the base to which bonuses are applied is abnormally low. The stimulation of productivity through incentive remuneration is limited unless the worker can feel sure that demonstrating his ability to produce more will not result in lowering his basic wage.

[81] U. S. Bureau of Labor Statistics, Bulletin No. 474, Productivity of Labor in Merchant Blast Furnaces, 1928, pp. 46–47.

Wage incentive plans adopted by the Bethlehem Steel Corporation prior to 1928 apparently increased both labor productivity and earnings.

In relining open hearth steel ladles costs have decreased 14.4 percent while the average earnings of the employees increased 21.3 percent. On track repair work costs were decreased 34 percent while the average earnings of the employees increased 25 percent. In making repairs to soaking pits costs were decreased 20.4 percent while the average earnings of the employees increased 19 percent.[82]

A successful bonus plan has been in operation for 10 years for packing and shipping employees of the Detroit Steel Products Co. "For 18 to 18½ units of work per man-hour, a bonus of 3 percent is added to each base rate, and a varying percentage is paid for increases above this level, till at 21 units or over 15 percent bonus is paid." Though the workers in this department have earned "close to 15 percent above base pay", "costs have been 10 percent lower over the period."[83]

Piece rates as an incentive to stimulate output have been widely used in this country.[84] But at the present time a shift back to rationalized hourly rates appears to be taking place. This can be ascribed in large part to (1) the increasingly automatic nature of modern machinery and (2) the provisions of the Wages and Hours Act which discourage the payment of piece rates.

The Minnesota study of changes in job requirements described the first factor as follows:

The reasons for this general movement are to be found in the changing nature of industry itself. After bonus or piece-rate systems had prevailed for many years, rates and standards could be set for most operations on the basis of careful time and motion studies. Moreover, with continuing technological advance and refinement, speed of performance became less and less a matter of choice for the individual worker. Thus, once a definite measure of a day's work on a particular operation had been established, management found that a flat hourly rate would eliminate costly bookkeeping, as well as tension on the part of the worker, without in any way decreasing the speed or quality of the work.[85]

Scientific Management and Material Conditions of Manufacture.

The better arrangement of work places, tools, materials, etc., in manufacturing plants has frequently resulted in considerable increases in labor productivity by reducing the amount of handling required. Better lighting and ventilation also contribute to productivity.

A Bureau of Labor Statistics study of the tire industry lists the effect on labor of various technological changes. The rearrangement of the curing room to take care of increased production saved 173 man-hours per day (at full capacity), or 22 men displaced. The moving of the preparation conveyor in the tube room and the rearrangement of the service conveyor and automatic soapstoning displaced 2 girls per shift, saving 48 man-hours per day. The consolidation and rearrangement

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[82] International Labour Office, The Social Aspects of Rationalisation, Geneva, 1931, p. 37.

[83] W. C. Owen, "Bonus Drops Packing Costs 10 Percent," Factory Management and Maintenance, vol. 97, No. 3, March 1939, pp. 51–52.

[84] The National Industrial Conference Board reported that in 1928 less than 15 percent of a sampling of plants employing more than 1,500 workers paid their employees on a straight-time basis. (Systems of Wage Payment, 1930, pp. 6–7.)

[85] Work Projects Administration, National Research Project, and Employment Stabilization Research Institute, University of Minnesota, Changes in Machinery and Job Requirements in Minnesota Manufacturing, 1931–36, by C. A. Koepke and S. T. Woal, 1939, p. 24.

of the cutting and rerolling departments displaced 14 girls and saved 112 man-hours per day.[86]

One department, which employs 30 to 40 girls, of the Maiden Form Brassiere Co. is engaged solely in clipping off the tiny ends of thread left after each sewing operation. When a scientific study of this department was undertaken, a total of 94 operations and 52 transportations were performed by each worker with both hands on each garment with an average of 27 threads to clip. Then scientific, semi-circular workplaces were devised, the girls sitting on posture chairs with adjustable footrests to take care of differences in height. These replaced ordinary tables and chairs and eliminated the hunched-up position the girls formerly assumed at work. The operations performed by both hands were reduced to 47, a decrease of exactly 50 percent, and the transportations by both hands were reduced by 51.9 percent. Production was accordingly increased with lower unit costs.[87]

The ordinary flat-top bench long used in packing one of the standard products of the Bristol Co. was replaced by a semi-circular bench with removable partitions to divide it into compartments of any desired size. The compartments all converge to the working space of about 30 by 12 inches, eliminating excessive reaching. This scientifically devised workplace has cut direct labor costs 40 percent, the operation is much less fatiguing, and operators' earnings have not been reduced.[88]

A program of lighting modernization by a large manufacturer of church, school, and theater furnishings has resulted in an average production increase of 5 percent, with some departments increasing output by 15 percent. The new equipment cost about twice as much as that replaced but the increased output due to better lighting has meant a saving of $250 per day, or about $75,000 per year.[89]

"Prior to the installation of air-conditioning equipment, a large printing company was compelled to stop work on days when natural humidity and temperature exceeded certain limits. With the ability to maintain continuously the desired temperature and humidity conditions, production is uninterrupted, and the uniformity and quality of the work have been improved. Of equal or greater importance is the fact that the ease of operating the existing plant at full capacity eliminated the need for increasing the size about 50 percent to take care of production requirements." [90]

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[86] U. S. Bureau of Labor Statistics, Bulletin No. 585, "Labor Productivity in the Automobile Tire Industry," by Boris Stern, p. 25.

[87] J. J. Baer, "More for the Company, More for the Girls," Factory Management and Maintenance, vol. 97, No. 2, February 1939, pp. 54–55, 114–116.

[88] Arthur R. Baldwin, "Motion-Economized Bench—Costs Off 40 Percent," Factory Management and Maintenance, vol. 97, No. 11, November 1939, p. 33.

[89] Factory Management and Maintenance, vol. 97 No. 11, November 1939, p. 70.

[90] Ibid., p. 74.

CHAPTER II

THE EFFECTS OF LABOR-SAVING TECHNOLOGY

TECHNOLOGY AS A CAUSE OF UNEMPLOYMENT

THE GENERAL EXTENT OF TECHNOLOGICAL DISPLACEMENT

The extent of technological unemployment is difficult to appraise. Sufficient specific instances of displacement of workers by technological improvements are marshaled together in this chapter, it is hoped, to leave no doubt that displacement has occurred and to give some perspective of its impact upon our economy.

Many estimates have been made of the amount of technological unemployment. In February 1940, the Congress of Industrial Organizations estimated on the basis of admittedly rough data, that "Unemployment of between two and one-half million and three million can be attributed to technological changes affecting the various kinds of employment."[1]

Stress has frequently been laid upon technology as a principal cause of unemployment prior to 1929. David Weintraub estimated that for manufacturing as a whole in the period 1920–29, 32 men out of every 100 required in 1920 were made unnecessary by increases in output per man, but of that number increases in the total output absorbed 27. His figures show that improvements in efficiency in this period displaced 2,832,000 men, or 416,000 more than were reabsorbed into manufacturing by the shortening of the work week and the increase in total output.

Weintraub estimated that 345,000 workers were displaced by increased technological and managerial efficiency in steam railroads during the same period. Technological displacement in the bituminous coal and anthracite industries was placed at 95,000 by his calculations. For these four major industries—manufacturing, steam railroads, bituminous coal and anthracite mining—Weintraub estimated an employment decline during 1920–29 of 3,272,000, resulting from changes in productivity. Meanwhile, 2,269,000 men were required to handle increases in volume of output, leaving a net decline of employment in these industries of 1,003,000.[2]

A comparison of separation rates in manufacturing industries from 1899–1929 made by Frederick C. Mills shows that during each 2-year period between 1923 and 1929, 49 workers out of every 1,000 withdrew from, or were forced out of, the industry in which they were working, compared with 21 men out of every 1,000 during each 5-year period from 1899 to 1914. This increase in the separation rate at a time of

[1] The Economic Outlook, February 1940.

[2] David Weintraub, "The Displacement of Workers Through Increase in Efficiency and Their Absorption by Industry, 1920–31," Journal of the American Statistical Association, December 1932, pp. 396–397

comparatively intense industrial activity is probably due to technological displacement. Mills also found that between 1923 and 1929 one worker out of 20 was compelled to seek employment in a new manufacturing industry or in a non-manufacturing industry every 2 years, a turn-over which at that time could not be ascribed to any major decrease in industrial activity.[3]

Labor-saving effected by technology during the last decade may be estimated from the indexes of production and productivity given in table 1. Manufacturing work which required 100 workers in 1923 could have been performed by 76 workers in 1929 and by 57 in 1939, assuming no change in weekly hours. Work which required 100 men in 1923 could have been performed in bituminous coal mining by 93 workers in 1929 and by 70 in 1939; in anthracite mining by 104 workers in 1929 and by 58 in 1939; and in steam railroads by 85 workers in 1929 and by 65 in 1939, again assuming no change in weekly hours.

Since each of these basic fields was characterized not only by an increase in labor productivity but also by a decline in production between 1929 and 1939, the aggregate number of man-hours was materially reduced. Total man-hours in manufacturing fell from 19,888,000,000 in 1929 to 14,948,000,000 in 1939; in bituminous coal mining total man-hours fell from 916,250,000 to 508,300,000; in anthracite mining from 271,853,680 to 104,463,420; and in steam railroads from 4,103,000,000 to 2,325,000,000. If no change in weekly hours had occurred in the last decade, these reductions in man-hours would have meant a displacement of 2,078,600 wage-earners in manufacturing, 761,678 in steam railroads, 204,143 in bituminous coal mining, and 87,762 in anthracite mining, or a total in all four fields of 3,132,183 wage-earners.

Since average weekly hours decreased over this period in each of the fields—17.7 percent in manufacturing, 31.2 percent in steam railroads, 29.4 percent in bituminous coal mining, and 24.1 percent in anthracite mining—the actual decline in the number of wage-earners was considerably less than this potential displacement. The number of wage-earners fell 723,700 in manufacturing, 729,000 in steam railroads, 98,000 in bituminous coal mining, and 70,500 in anthracite mining, or a total decline of 1,621,200 wage-earners.

It is impossible with existent data to determine precisely the role of technology in causing potential and actual reductions in employment where a decline in production has occurred. But a comparison over a period of years of changes in the total number of man-hours required to produce a comparable output demonstrates rather clearly the extent of technological unemployment. This method is best suited to a comparison of years of relatively high output, since a marked advance in productivity can usually be expected to occur upon a comparatively small increase in production when production is at a relatively low level during the base period. Consequently, comparisons for specific industries in this analysis are made between 1929 as a base and a year of approximately comparable production in the late thirties.

[3] Frederick C. Mills, Economic Tendencies in the United States, National Bureau of Economic Research, New York, 1932, pp. 419–423.

Sufficient data on production and man-hours are available for a comparison of this nature for 12 industries. The percentage change from 1929 to the year in the late thirties during which production approached most closely the 1929 level strikingly reveals the influence of technology upon the total amount of labor required. In 4 of these 12 industries the decline in man-hours amounted to over 30 percent; in 5 more the decline was from 20 to 30 percent; in 2 it was from 10 to 20 percent; and for 1—bread and other bakery products—man-hours dropped only 0.5 percent. The percentage change in both production and man-hours in these industries for years of approximately comparable production is shown in chart VII, table 7.

TABLE 7.—*Percentage change in production and man-hours in 12 industries*

[1929=100]

Year of approximate comparable output in the 1930's	Industry	Production	Man-hours
1937	Iron and steel	99.9	87.9
1935	Petroleum refining	98.1	66.4
1938	Chemicals	94.1	77.0
1937	Fertilizer	97.7	65.2
1939	Paints and varnishes	102.3	78.1
1937	Cotton goods	104.6	79.3
1938	Boots and shoes	105.9	76.8
1938	Paper and pulp	102.3	78.3
1937	Newspapers and periodicals	104.3	84.5
1937	Bread and other bakery products	99.4	99.5
1936	Confectionery	102.5	64.4
1938	Ice cream	102.6	67.7

Source:
Production: Victor Perlo and Witt Bowden, "Unit Labor Cost in 20 Manufacturing Industries, 1919–1939," U. S. Bureau of Labor Statistics, Monthly Labor Review, July 1940, p. 37.
Man-hours: National Research Project figures (Production, Employment, and Productivity in 59 Manufacturing Industries, Part II) extended by the use of U. S. Bureau of Labor Statistics data.

The significance of these comparisons lies not only in the sharp decreases in the number of man-hours required to produce a generally comparable amount of goods, but also in the wide range of activities represented. The substantial decreases in man-hours which took place in all but one of these industries between years of relatively high output indicate that the adoption and utilization of labor-saving innovations has by no means been confined to any small segment of the economic system.

A comparison of total man-hour requirements in years of approximately comparable output overcomes the difficulty of allowing for changes in labor productivity at varying rates of production. Unfortunately, production is rarely at a level exactly comparable with a preceding year.

If this method is to be used, comparisons must be extended to years of approximately comparable rates of output. What constitutes approximately comparable production depends upon an arbitrary determination. But for practical purposes two given years are regarded as approximately comparable when their rates of production are within 10 percent of each other.

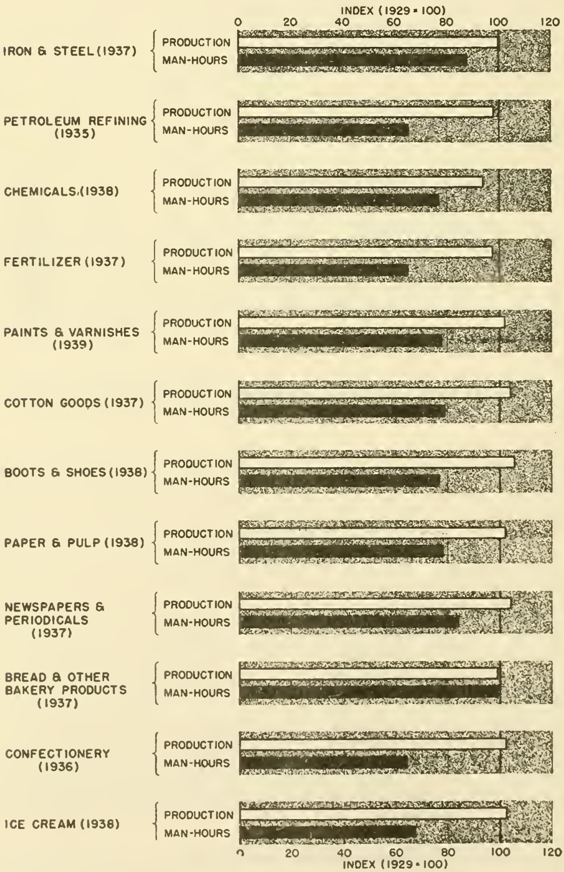
If production is at a generally similar level in the two years compared, but in the latter year is a few percent above the level of the former year, that increase in production might result in a consider-

Chart VII

CHANGES IN PRODUCTION AND MAN-HOURS

12 INDUSTRIES IN THE UNITED STATES

(FROM 1929 TO YEAR OF APPROXIMATELY COMPARABLE OUTPUT IN THE THIRTIES)



Source: Table 7

able advance in labor productivity, particularly if the comparison is made between years of relatively low output. The selection of sets of years for comparison in which production is lower in the latter than in the former year would tend to prevent the appearance of exaggerated productivity increases. The difficulty then arises that part of any decline in the amount of labor required could be accounted for by the drop in production. Adjustments may be made for this factor, however, by reducing the total labor requirements in the former year by the percentage decline in production between the two years.[4]

In manufacturing, production in 1939 was at almost exactly the same level as in 1929. In steam railroads and bituminous coal mining. 1930 and 1937 were years of approximately comparable output. Therefore, comparisons between these sets of years highlight the extent of technological displacement in these three fields and are set forth in table 8.[5]

TABLE 8.—*Technological displacement in manufacturing, steam railroads, and bituminous coal mining, 1929–39*

Year	Production (1923=100)	Man-years [1]	Adjusted man-years [2]
MANUFACTURING			
1929	130.1	8,368,800	8,326,956
1939	129.5	6,290,186	6,290,186
Actual change	−.6	−2,078,614	−2,036,770
Percent change	−.5	−24.8	−24.5
STEAM RAILROADS			
1930	88.7	1,563,000	1,464,531
1937	83.1	1,168,981	1,168,981
Actual change	−5.6	−394,019	−295,550
Percent change	−6.3	−25.2	−20.2
BITUMINOUS COAL MINING			
1930	82.8	440,700	419,987
1937	78.9	379,449	379,449
Actual change	−3.9	−61,251	−40,538
Percent change	−4.7	−13.9	−9.7

[1] Based on average weekly hours: 45.7 in manufacturing (1929); 43.2 in steam railroads (1930); and 33.5 in bituminous coal mining (1930).

[2] Adjusted for the percentage declines in production: 0.5 percent in manufacturing, 6.3 percent in steam railroads, and 4.7 percent in bituminous coal mining. Table 1, supra.

Source: Computed from U. S. Bureau of Labor Statistics, Monthly Labor Review, September 1940, "Wages, Hours, and Productivity of Industrial Labor, 1909 to 1939" by Witt Bowden.

Had there been no changes in weekly hours, the 1929 output in manufacturing could have been produced in 1939 with 2,036,770 fewer wage-earners, a 24.5 percent reduction in a decade. The 1930 output could have been produced in 1937 with 295,550 less wage-earners in steam railroads[6] and 40,538 fewer in bituminous coal

[4] For example, if man-years are at 8,000,000 in the former and 6,000,000 in the latter year and production falls 10 percent between the years, the amount of technological displacement would be 1,200,000 man-years (8,000,000 man-years minus 10 percent, or 7,200,000, minus the labor engaged in the latter year, 6,000,000 man-years).

[5] Derived from the production and man-hour data in table 1, p. 90.

[6] Changes in total labor expenditures in steam railroads are occasionally attributed to fluctuations in the proportion which maintenance workers are of all railroad employees, i. e., to changes in management policies toward the amount of maintenance required for

mining,[7] reductions of 20.2 percent and 9.7 percent, respectively, within only 7 years.

The seriousness of a technological displacement of over 2,000,000 adjusted man-years in manufacturing during one decade, of nearly 300,000 in steam railroads, and of over 40,000 in bituminous coal mining in only 7 years requires no elaboration.

DISPLACEMENT IN SPECIFIC INDUSTRIES

Certain industries present striking case histories of the impact of technology upon employment. For example, the electric lamp industry illustrates the increase of labor productivity through the introduction of revolutionary new mechanical techniques. In making and assembling the parts of an electric lamp there have been two developments of outstanding importance. First is the group or unit system of manufacture, which coordinates and synchronizes such related parts of a production unit as the bulb-making machine, the hot belt conveyor and the burn-off machine. Second is a widely used mechanism consisting of a turret or spider rotating on a vertical axis operated by electric motor which performs automatically many of the functions formerly done by manual labor.[8]

How technological improvements in this industry, of which only two have been mentioned, have reduced total man-hours needed in electric lamp assembly plants during the period 1920–31, in the face of a rapidly growing output, is shown in the following table. It is especially significant because the major portion of the labor in the electric lamp industry is employed in lamp assembly plants.

Production and employment in electric-lamp-assembly plants, 1920–31[9]

Year	Production (number of lamps)*	Employment (number of man-hours)	Year	Production (number of lamps)	Employmen (number of man-hours)
1920	362,140,000	36,145,000	1926	482,455,000	17,576,000
1921	242,515,000	21,710,000	1927	544,512,000	17,922,000
1922	311,265,000	24,549,000	1928	556,953,000	15,976,000
1923	404,226,000	26,821,000	1929	643,957,000	16,003,000
1924	435,172,000	22,079,000	1930	553,199,000	13,424,000
1925	459,275,000	19,753,000	1931	503,350,000	11,448,000

[9] Ibid., table 5, p. 39.

The upward trend of production until 1929 was accompanied by a marked decline in the number of man-hours. Only 16,003,000 man-hours were required to produce 643,957,000 lamps in 1929; in 1920 over twice that number of man-hours were required to produce a little more than half as many lamps. It is estimated that 16,049 employees were displaced by technological advances in electric-lamp assembly plants between 1920 and 1929.[10]

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a specific year. However, this factor does not affect the comparison of 1930 and 1937 because the proportion of maintenance workers to all railroad employees was almost the same for the two years, being 49.9 percent in 1930 and 48.6 percent in 1937. (Interstate Commerce Commission, Wage-Statistics of Class I Steam Railways in the United States, issues for the years indicated.)

[7] This displacement does not include the amount of labor lost in bituminous coal from the production decreases due to the substitution of other fuels.

[8] U. S. Bureau of Labor Statistics, Bulletin No. 593, 1933, "Technological Changes and Employment in the Electric Lamp Industry," by Witt Bowden.

[10] Ibid., p. 43.

The growing importance of labor-saving machinery in this industry is strikingly shown by a comparison of labor productivity from 1916 to 1932 in the production of glass bulbs of a standardized type, the 25-watt bulb (table 9).[11]

TABLE 9.—*Estimated changes in the productivity of hand and machine labor in selected plants in making glass bulbs for 25-watt electric lamps*

Method of production	Year	Output per unit-hour (bulbs)	Output per man-hour	
			Bulbs	Index (output in plant A=100)
Hand production:				
Plant A	1916–19	118.2	52.5	100.0
Plant B	1923 [1]	126.5	56.2	107.0
Semiautomatic machine (Empire E)	1925 [2]	406.2	116.1	221.1
Automatic machine (Empire F)	1925 [1]	1,870.6	801.8	1,527.2
Automatic:				
24-spindle Westlake, old type	1925	2,139.5	1,284.2	2,446.1
24-spindle Westlake, new type	1925 [3]	2,336.9	1,699.3	3,236.8
Do	1931–32 [4]	3,537.7	2,573.7	4,902.3
48-spindle Ohio	1931–32 [5]	6,242.2	4,538.9	8,645.5
Ribbon bulb machine	1932 [6]	20,762.0	----------	----------

[1] 7 months. [2] 4 months. [3] 11 months. [4] 14 months. [5] 16 months. [6] 6 months.

Source: U. S. Bureau of Labor Statistics, Bulletin No. 593, 1933, "Technological Changes and Employment in the Electric Lamp Industry" by Witt Bowden, table 8, p. 45.

Just as the electric lamp industry shows the effect of revolutionary mechanical techniques, the automobile tire industry is an example of the increase in labor productivity through the gradual but constant introduction of numerous, small, detailed innovations in the productive process. Major changes in the processes of tire manufacture have been few and far between. Up to 1933 there had occurred only one major change in the manufacture of pneumatic tires: The replacement of the core process by the flat-drum process, a change which by 1927 had taken place in all the major plants. A list of some of the typical minor changes, which in their cumulative effect have raised labor productivity extensively in tire-making, is presented in appendix G.

The trend of production in the tire industry up to 1929 was markedly upward, but total man-hours remained remarkably stable. The difference between the actual changes in total man-hours worked and the increases or decreases in man-hours brought about by changes in total output represents the reduction in total labor time caused by technological change or the total volume of labor displaced. A computation of the amount of labor displaced by technology from 1922–31, together with output and man-hour figures, is given in table 10.

[11] The indexes do not reveal the full extent of the change in productivity because comparable figures on the most recent improvement—the so-called ribbon bulb machine—were not available for the study. The output of a single unit for 24 hours runs above 500,000 bulbs, but the exact number of man-hours was not known and therefore the index of man-hour output is omitted. (Ibid., table 8, p. 45.)

TABLE 10.—*Actual production and volume of technological labor displacement in 6 representative tire plants, 1922 to 1931*

ACTUAL PRODUCTION

Year	Total output pounds	Total man-hours	Technological displacement in man-hours
1922	295, 222, 000	26, 165, 000	
1923	324, 544, 000	26, 431, 000	2, 122, 000
1924	357, 863, 000	28, 161, 000	892, 000
1925	466, 238, 000	33, 860, 000	2, 171, 000
1926	501, 513, 000	30, 427, 000	5, 573, 000
1927	599, 642, 000	31, 867, 000	3, 775, 000
1928	752, 333, 000	35, 885, 000	3, 265, 000
1929	801, 725, 000	35, 167, 000	2, 885, 000
1930	684, 645, 000	26, 166, 000	3, 866, 000
1931	648, 648, 000	21, 150, 000	3, 640, 000
Cumulative effects, 1922–31 [1]			28, 189, 000

[1] Result obtained by subtracting total decrease from total increase.

Source: U. S. Bureau of Labor Statistics, Bulletin No. 585, 1933, "Labor Productivity in the Automobile Tire Industry," by Boris Stern, p. 17.

In both of the two major segments of manufacturing, steel and textiles, marked advances in labor productivity have recently taken place.

The steel industry between 1937 and 1939 was characterized by an increasing displacement of labor, due in large part to the introduction of continuous strip mills. In 1937 the maximum work week in the steel industry was reduced from 48 to 40 hours in certain companies, and, consequently 58,690 more workers were required in September 1937 to produce a tonnage equivalent to that of August 1936. This increased employment, however, was nullified during the next 2 years by technological advance. The number of wage earners in the 2-year period from September 1937 to September 1939 decreased from 503,000 to 415,000, an elimination of more than 88,000 workers, or a decline of 17.5 percent in the number of steel workers needed to produce an equivalent tonnage. Compared with August 1936, when the maximum hours were 8 per week higher, the number of steel workers in September 1939 was 30,000 less.[12]

Some specific examples of the impact of new steel technology were presented by Philip Murray before the Temporary National Economic Committee in its hearings on Technology. Certain of his more striking examples are given below in summary form:

(1) A large steel company invested $750,000 in improvements in its open hearth department. Sixty-two employees were eliminated as a result of the improvements which effected an annual pay roll saving of $118,000. In addition, savings in coal consumption and in other lines amounted to $257,000 a year. Thus the company's annual savings in cost totaled $375,000, or enough to write off its $750,000 investment and interest in less than 2½ years. The technical improvements enabled the men remaining on the pay roll to produce in 133 days the same amount of steel that formerly required 200 days.

(2) One of the industry's largest wire companies through technical improvements increased the speed of its cold wire drawing machines from 115 revolutions to 150 per minute. Production rose from 2,185 pounds per 8-hour turn to 3,000 pounds per turn, or an increase of 37 percent. In another case, a wire company in its fine wire department increased the revolutions of its machines from 350 to 450 per minute, or 28 percent. Production rose from 1,200 to 1,800 pounds per 8-hour turn, or 50 percent. Here again the 12-month employment year was cut at least by one-fourth.

(3) In the steel foundry of the Bethlehem Steel Co., five to six chippers formerly worked 8 hours each to clean the scale from a certain product, at a

[12] Hearings before the Temporary National Economic Committee, Part 30, p. 16489.

total labor cost for this one operation of $31.20. Now one scarfer with an acetylene torch and one helper does this same job at a labor cost of $10.08, or a reduction in the total labor cost of 70 percent. At least 2,500 workers have been eliminated in the steel industry during the past decade by the shift from the chipping to scarfing method for taking bad seams out of slabs, billets, etc.

In describing the inclusive nature of the many technological changes, Mr. Murray observed:

I can cite numerous other cases, and the story is the same: One man here, three men there, a dozen men here, and so forth are being displaced by technical improvements. The effects of these improvements have been that fewer and fewer workers and less and less man-hours are required to produce more and more steel products.[13]

Also, technological displacement of workers has occurred in the textile industries. For example, one concern in the viscose filament rayon industry changed its method of spinning and doffing and thereby displaced 1,100 workers; it is likely that many of the workers, thus displaced, will be without any opportunities for reemployment in their communities. In another textile plant, production per man-hour increased approximately 100 percent from June 1937 to June 1939 as a result of the installation of faster, more continuous machines, and the introduction of the cake-wash method. Employment at this plant declined 46.3 percent and production rose 10.2 percent in the same period. At another plant employment declined 26 percent and production increased 60 percent within 2 years.[14]

Most of the innovations in textile manufacture have been in the direction of continuous operation, speeding up, and larger sized equipment. The most impressive advance toward continuous operation has occurred in the spinning and finishing operations developed by the Industrial Rayon Co. at its Painesville, Ohio, plant. Spinning and finishing time has been reduced from the customary 85-hour period in plants with discontinuous procedures to less than 5 minutes. The elimination of numerous batch processes and the construction of compact spinning equipment permits the yarn to be washed, desulfurized, bleached, finished, dried, and twisted successively on the same machine. Large package bobbins have reduced the doffing time to once every 19.5 hours compared with the former 4- to 9-hour doffing time.[15]

THE DURATION OF UNEMPLOYMENT

A considerable proportion of those without work remain jobless for extended periods of time. During recent years, studies of duration of unemployment have been made by the National Research Project of the Work Projects Administration.[16] In Philadelphia an analysis of the duration of unemployment was made in May 1937, a month of considerable industrial activity. The survey was conducted by means of a house-to-house canvass in which 46,000 households, including about 9 percent of the estimated employable population of the city, were covered.

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[13] Ibid., p. 16479.
[14] Ibid., p. 16842.
[15] Ibid., p. 16841.
[16] A summary of the pioneering studies on the duration of unemployment—those of Lubin, Myers, Clague, and Couper, Bakke and Lumpkin—by David Weintraub and Harold Posner, is to be found in the report of the National Resources Committee, Technological Trends and National Policy, 1937, pp. 83–85.

Philadelphia is a center of industrial activity, particularly in the manufacture of specialized textile, metal, and chemical products and machinery and transportation equipment.

In 1930 about half of the gainful workers in the city were attached to the manufacturing and mechanical industries, in which various types of metal and machinery manufacturing, textile manufacturing, and building construction predominated. One-fifth of the gainful workers in 1930 were employed in trade, and the remainder in other types of industries.[17]

The duration of unemployment in this study was defined as "the length of time from the date of the loss of the last nonrelief job which lasted 1 month or more to June 1, 1937." Employment on Emergency Works Program projects was counted as unemployment. For the majority of workers the duration of unemployment represented the length of time they had been seeking work since the loss of their last job, but for an undetermined number it may have included some periods of time out of the labor market.[18]

The duration of unemployment for both men and women in Philadelphia, as of May 1937, is summarized in Chart VIII, table 11.

TABLE 11.—*Duration of unemployment since last nonrelief job, Philadelphia, May 1937*

ALL UNEMPLOYED

Duration of unemployment in months, total	Cumulative percentages		Duration of unemployment in months, total	Cumulative percentages	
	Men	Women		Men	Women
0 to 11	100.0	100.0	36 to 47	37.7	26.1
12 to 23	61.7	48.8	48 to 59	29.4	19.6
24 to 35	48.0	34.9	60 and over	21.6	14.2

Source: Works Progress Administration, National Research Project, Employment and Unemployment n Philadelphia in 1936 and 1937, Part II, May 1937, 1938, p. 26.

Long-term unemployment characterizes a substantial proportion of the jobless in this labor market. Forty-eight percent of the men and 34.9 percent of the women had been without private jobs (which lasted more than 1 month) for 2 years or over; 29.4 percent of the men and 19.6 percent of the women had been unable to obtain jobs for 4 years or more. The large proportion of women engaged in the textile and clothing industries, which were not so seriously affected as other industries by curtailment of production, probably accounts for their being less seriously affected than men.

The Federal Reserve Board reported that industrial production, adjusted for seasonal variation, had risen from the 1923–25 base of 100 to 118 by May 1937, compared with 122 for the corresponding month in 1929. Hence, the month studied was by no means one of unusually depressed conditions. Yet a fourth of the persons in this labor market in May 1937 were totally unemployed.[19]

The seriousness of the duration of unemployment is even more acute in particular fields of work. For example, men customarily

[17] Works Progress Administration, National Research Project, Recent Trends in Employment and Unemployment in Philadelphia, 1937, p. 3.

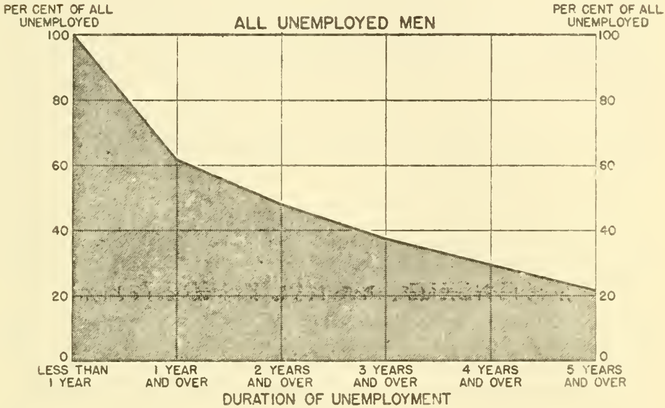
[18] Works Progress Administration, National Research Project, Employment and Unemployment in Philadelphia in 1936 and 1937, Part II, May 1937, p. 24.

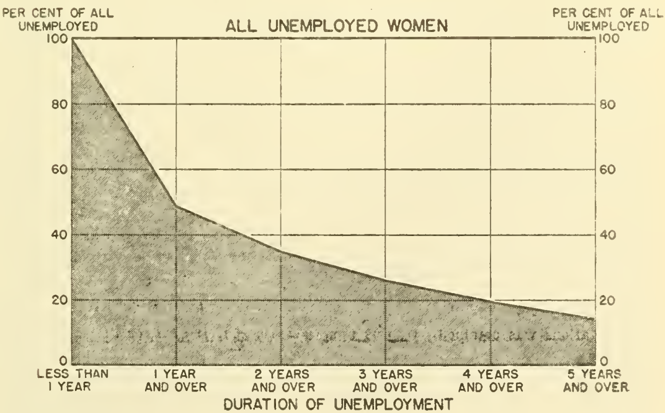
[19] Works Progress Administration, National Research Project, Employment and Unemployment in Philadelphia in 1936 and 1937, Part II, p. 11.

CHART VIII

DURATION OF UNEMPLOYMENT SINCE LAST NON-RELIEF JOB

PHILADELPHIA, MAY 1937





Source: Table 11.

employed in the manufacture of transportation equipment had been out of work in May 1937, for an average of 40.2 months; those usually employed in the manufacture of metal products for 39.3 months. An average of 34.3 months of unemployment was reported by men normally working for public utilities, and 31.5 months by men in the building and construction field.

The role of technology in long-term unemployment cannot be precisely determined, but it is undoubtedly great. When a labor-saving technique takes the place of a worker, the duration of the affected worker's unemployment is likely to be extended. Frequently he must seek work in an industry new and foreign to his experience. If a mature and skilled worker, he may prefer to await the possibility that new work in his field will develop rather than to seek a less skilled and lower paid position in another field. Often, owing to the practice followed by many firms of filling their unskilled and semiskilled job openings with young men who are new entrants to the labor market, the mature but displaced worker can find no employment even in an expanding field. Furthermore, it is difficult, if not often impossible, for him to move readily about the country, seeking a field of expanding employment.

For these and related reasons, technological unemployment is likely to be long-term unemployment. Concrete evidence of this is attested in the above-cited study: In the industries in which technological advances have been greatest there are large numbers of unemployed who have remained jobless for long periods. For example:

> The highest average duration of unemployment for women was reported by those usually employed in public utilities (40.0 months), especially in telephone and telegraph companies.[20]

TECHNOLOGY AND THE DISPLACEMENT OF SKILL

Technology not only reduces the *amount* of labor required to perform a given function; it also brings about changes in the *type* of labor required, which often involve a displacement of skill.[21] This

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[20] Ibid., p. 28. The widespread extent of this long-term unemployment is corroborated by the Census of Unemployment in Massachusetts, taken in 1934.

"The questionnaire used in securing information with reference to the duration of unemployment of persons who were unemployed included two inquiries, as follows: (a) Duration of unemployment since last employed at any occupation, and (b) duration of unemployment since employed at customary occupation. These two phases of the subject are here considered separately.

"The total number of persons who were reported as wholly unemployed since their last employment at any occupation was 346,021. For 341,127 of these persons the duration of unemployment was reported, and of this number 134,913, or 39.5 percent, had not been employed at any occupation for 1 year or less; 62,482, or 18.3 percent, for 1 year but less than 2 years; 65,767 or 19.3 percent, for 2 years but less than 3 years; 42,621, or 12.5 percent, for 3 years but less than 4 years; and 35,344, or 10.4 percent, for 4 years or over. For males and females the distribution, according to duration of unemployment was quite similar, except that in the case of the females the percentages unemployed for periods of shorter duration were higher than the corresponding percentages for males.

"The total number of persons who were reported as wholly unemployed, temporarily employed, and employed part-time was 624,526. For 615,889 of these persons information as to the duration of their unemployment since they were last employed at their customary occupations was obtained. Of this number (615,889), 190,724, or 31.0 percent, had not been employed at their customary occupations for 1 year or less; 115,013, or 18.6 percent, for 1 year but less than 2 years; 137,808, or 22.4 percent, for 2 years but less than 3 years; 92,985, or 15.1 percent, for 3 years but less than 4 years; and 79,359, or 12.9 percent, for over 4 years. For males and females the duration of unemployment since they were last employed at their customary occupations was quite similar, except that in the case of females the percentage (37.3) unemployed for 1 year or less was higher than the corresponding percentage (28.7) for males. (Massachusetts Department of Labor and Industries, Report on the Census of Unemployment in Massachusetts, 1934, pp. 18–19.)

[21] "By displacement of skill * * * is meant the loss of the opportunity to sell acquired skill at the rate of remuneration which would have been received if the machine had not been introduced. Displacement, therefore, does not necessarily mean loss of

displacement is limited by the amount of skilled workmanship in modern industries. In the words of Harry Jerome:

> The potential displacement of skilled labor by the further substitution of machine methods for hand processing is limited by the fact that, while there are still many hand workers in industry, the number engaged in hand crafts that are of a distinctly skilled type is relatively small, especially if we exclude the building industries. * * * [22]

PATTERNS OF SKILL-DISPLACEMENT

Techniques which displace skill are generally of three basic patterns: (1) Those designed for one specific operation—special-purpose techniques; (2) those so designed that with slight modification they can be applied to other operations—general-purpose techniques; (3) those which go through successive radical changes, after being applied to a specific operation, culminating in entirely new and even more efficient techniques.

A simple example of the first pattern is the replacement of skilled stonecutters by mechanical stoneplaners. As early as 1915, a single-platen planer of improved type could do as much work in an hour as 10 stonecutters.

> It may be roughly estimated that in 1900 there were between 20,000 and 25,000 stonecutters in the United States. The labor-saving devices introduced in the trade, chiefly after 1900, did in 1915 an amount of work which, at the lowest estimate, would have required the labor of 10,000 hand cutters. By 1915 probably one-half of the stonecutters had been displaced from the trade.[23]

An improved wood shaper now turns out special shapes of ironing boards. The operator simply stacks a number of boards which are cut and shaped at one time by the machine; he then removes the cut boards and inserts others. Formerly, a moderately skilled worker manipulated a single ironing board around the cutting tool until the edges were smooth and even.[24]

Highly skilled wood carvers in the furniture industry have been displaced to a considerable extent by wood carving machines, which can produce up to 24 identical carvings from a master form. Replacing the skilled carver is a semiskilled operator who is generally incapable of carving with hand tools. Only a few of the craftsmen are retained—and these only in the large furniture factories—to make the original master forms.[25]

Craftsmanship is disappearing also in the pottery industry. The potter's wheel is rarely used. Instead, a plaster-of-paris mold is filled with fluid clay, and later a comparatively unskilled worker breaks open the mold to discharge the ware.[26]

Special-purpose techniques are much more limited as to skill-displacing potentialities than those which can be applied to a number of occupations. Industrial instruments exemplify the general-purpose

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employment. If the employment after the introduction of the machine, and as a consequence thereof, is at a lower rate of remuneration, displacement of skill has occurred." (George E. Barnett, Machinery and Labor, Harvard University Press, Cambridge, 1926, p. 117.)

[22] Mechanization in Industry, National Bureau of Economic Research, New York, 1934, p. 397.

[23] Barnett, op. cit., p. 34.

[24] Work Projects Administration, National Research Project, Changes in Machinery and Job Requirements in Minnesota Manufacturing, 1931–36 by C. A. Koepke and S. T. Woal. 1939, p. 9.

[25] Ibid., p. 44.

[26] Ibid., pp. 44–45.

type of skill-displacement techniques. Their application has been steadily extended into a larger number of fields.

The skill-displacing potentialities of instruments which control are much greater than those which merely indicate or record. Of all the new instruments placed on the market during the period 1928–37 the number of the controlling type rose most sharply. In 1928 only 8 percent of the new instruments were control devices; by 1935 their proportion had risen to 40 percent. The proportion of recording instruments declined during this period from 15 to 11 percent and indicators fell from 78 to 49 percent.[27]

The widespread application of industrial instruments has resulted in a marked change in the composition of the labor force in numerous industrial operations, since the need for skilled labor is reduced when instruments simplify and standardize the method of work.

> An outstanding illustration (of this elimination of individual skills) is to be found in steel treating where, before the development and application of pyrometers, heat treating was assigned to skilled craftsmen who judged the temperature of the metal by observing its color. (A dull red color, for example, indicated low temperature, whereas white was a sign of high temperature.) A worker had to have considerable skill and training to be able to gage metal temperatures correctly at the several stages of the heat-treating process, and only experienced craftsmen were able to produce high-quality products. * * * Pyrometers (during the 1920's) had eliminated the need for perceptory skill, and the operator now merely followed instructions prepared by the plant metallurgist. Although the worker had to possess some skill in order to follow the instructions, the responsibility for quality no longer rested on his shoulders alone, since he relied not only on the metallurgist but on the pyrometer as well. When, more recently, automatic temperature control of heat treating was developed, the process became highly standardized and the last elements of skill were eliminated.[28]

In recent years changes of almost revolutionary character have affected certain basic stages of metal work. The most striking are stamping and welding. Each of these general purpose techniques has been known for years, but has been progressively extended to a growing number of fields. When metals were formed into shape with planers, lathes, broachers, shapers, and files, the skill requirements per unit of output were among the highest in the industrial world. But today, the role of many metal workers is becoming increasingly that of an attendant to a machine which batters and hammers the metal into form with tremendous force and extreme precision at an almost incredible speed. This machine is the punch press. The punch press and closely related types of equipment are today capable of trimming, shearing, parting, notching, blanking, punching, piercing, bending, beading, expanding, curling, contracting, burring, wiring, drawing, extruding, forging (hot and cold) swaging, flanging, embossing and pinching.[29]

"Because of flexibility in feeding stock and discharging work, these presses have proved to be profitable investment in the production of an endless variety of metal stampings for automotive and aircraft parts, refrigeration and air-conditioning equipment, radios, electrical equipment and appliances, agricultural implements, business machines, stoves, hardware, toys, containers, and tinware." (*Iron Age*, January 4, 1940, p. 297, advt.)

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[27] Works Progress Administration, National Research Project, Industrial Instruments and Changing Technology, 1938, pp. 44–46.
[28] Ibid., p. 86.
[29] Raymond F. Yates, Machines over Men, Frederick A. Stokes Co., New York, 1939, p. 138.

The speed of the punch press has been steadily increased. One punch press recently developed delivers 1,200 strokes per minute and operates with a continuous-feed mechanism; unit punch set-ups have been developed for automobile work which punch up to 52 holes at once. In fact, it is now possible "to speed up presses to a maximum production, limited largely by ability of the equipment to discharge finished work." [30]

The amount of skill per unit of output has been decreased not only by the speed of these modern battering rams; their very development has completely eliminated certain functions formerly performed by skilled workers.[31] The increasing use of the stamping process has so lowered labor requirements that certain types of presses are reputedly capable of returning initial investment in from 60 to 90 days of full-time operation.[32]

Not many years ago the electric arc and the acetylene torch were regarded merely as tools for repair. The development of the resistance welder and the spot welder (which automatically ceases functioning upon attaining the precise conditions desired in the metals being fused) has practically displaced the riveter, formerly a highly skilled worker in a number of the steel trades.

The most striking use of spot welding is in large jigs, particularly in the automobile industry. In the production of 1940 automobiles a new method of spot welding fused a 4-door sedan together almost instantly at 222 points. In this type of automatic application, spot welding represents more than a transition from the skilled riveter to the welder, since the mechanism, after being set in motion, advances to the correct temperature, fuses numerous points, and then ceases operation, with hardly any human labor involved.

Even where welding is not performed automatically in a large jig, improvements have reduced considerably the amount of skill required on the part of the individual welder, especially through automatic tracing of patterns by means of magnetic attraction. The science of welding has been so developed that the worker only needs to know how to make good welds. A lengthy experience with the process and an intimate knowledge of metals are no longer requisites of the occupation.[33]

The skill-displacement caused by the punch-press and the spot-welding process is reflected in the occupational requirements of an industry in which they are widely used. It has been reported that in the plants of one large automobile company 43 percent of the workers require only 1 day to learn their jobs, 36 percent up to 8 days, 6 percent up to 2 weeks, 14 percent from a month to a year, and only 1 percent more than a year.[34]

The changes which have taken place in telegraphy exemplify the third pattern of skill displacement. In the larger offices (classed as functional offices) Morse operators had been largely displaced by

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[30] Steel, January 2, 1939, p. 320.

[31] As an instance, in the stamping and forming of metal in the production of valve rocker arms for automobile engines, the "part is composed of two halves, formed from identical steel sheet blanks. A hub is drawn in each half, so that when the two pieces are * * * brazed together, they form a complete arm and hub ready to receive a bushing. The hole is sized so accurately in the drawing operation that machining is unnecessary. Oil ducts are coined in each half, so that when brazing is finished, a complete oil line is formed, thereby eliminating a drilling operation." (Ibid., p. 320.)

[32] Ibid., p. 320.

[33] Ibid., p. 184.

[34] Hearings before the Temporary National Economic Committee, Part 30, p. 16372.

operators of teletypewriters by 1932. The productivity of printer operators was so great that approximately 50 percent of the number of operators who would be required for Morse manual operation had been displaced. In all offices combined the proportion of male operators had been reduced from about 80 percent to about 40 percent of the total, and the skill and training characteristic of Morse operators was supplanted by ability simply to operate a typewriter keyboard adapted to telegraphic purposes.[35]

Recently labor-displacement has been greatly increased by the introduction of improved mechanical features, particularly the Multiplex-Simplex repeater and the reperforator.[36] A reperforator installed in 1937 by one large communication company in Richmond, Va., displaced 70 percent of its entire personnel.[37]

The culmination of this skill-displacement would be reached if communications companies adopt a technique with which they are now experimenting, the facsimile machine. The customer simply writes out his own message, places it in a slot, pays a fee, and a facsimile copy of the message is automatically delivered at the other end.[38]

Printing methods have likewise been successively improved. Prior to 1890 the process of composition had not been greatly improved in 400 years, but about that time machine composition began to supplant type-setting by hand. Between 1887 and 1903 a total of 8,618 linotypes were manufactured in the United States and Canada. A linotype operator can set as much in 1 hour as a hand compositor can in 4. If 7,500 linotype machines were operated in 1904 the same number of hours each day as hand compositors formerly worked, potential displacement of hand compositors then was 30,000. Allowing both for the fact that many linotypes were run two or three shifts and that a reduction from 10 to 8 hours in the working day took place about this time, potential displacement of hand compositors by 1904 was about 36,000. Such a displacement did not take place because of the increasing quantity of printing done—an increase brought about largely by the adoption of the new technique. A skilled handcraft was, however, displaced by a machine operation requiring less skill.[39]

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[35] U. S. Bureau of Labor Statistics, Monthly Labor Review, March 1932, "Displacement of Morse Operators in Commercial Telegraph Offices," pp. 501–515.

"Each key on a (teletypewriter) keyboard represents a character, and the depressing of the key sets up an electrical contact which automatically operates the corresponding key on a similar keyboard at the receiving end. The contact may be established by direct keyboard action or by means of a perforated tape which is automatically fed through a transmitter, each set of perforations composing a code character corresponding to a character on the keyboard. At the receiving end the keyboard which automatically prints the message may be a tape-recording printer or a page printer. In either case the message is typed out, not in code but in ordinary printed characters. Several receiving machines may be operated on the same circuit by one transmitting machine." (Ibid., pp. 502–503.)

[36] The so-called Multiplex-Simplex repeater is "a device which comprises a portable table on wheels which can be connected with adapters on any trunk circuit and give direct service to any branch having a teletype machine." The labor-saving feature of this device consists in its elimination of relays. By its use messages are routed to centers which have direct and continuous operation to other localities; through this substitution of continuous for sporadic operation, the amount of labor required to handle a given number of messages has been considerably reduced.

A second improvement which has tended to reduce total labor requirements is the so-called reperforator. "(This device) consists of banks of relays, transmitters, and automatic equipment designed to eliminate jobs. Instead of the message being printed on a tape and gummed by an operator as before, it is received in the form of a perforated tape with the printed message above the perforated tape and is switched to its destination at the switching center and placed in a transmitter by the receiving or switching operator. One operator in the switching center can take care of the same number of wires that four operators formerly worked, thereby eliminating three operators who formerly had jobs. Furthermore, under this system the switching center operator must now also be a route-clerk. * * * thereby eliminating the route-clerk's job." (Hearings before the Temporary National Economic Committee, Part 30, pp. 16690–91.)

[37] Ibid., p. 16691.

[38] Ibid., p. 16692.

[39] See Barnett, op. cit., pp. 3–6. Unlike the teletype operator, the linotype operator is a skilled worker. The two examples are different in this respect.

Improvements were then made which reduced materially the amount of labor required to operate the new technique. The linotype of today is immeasurably more efficient than that of 1904. In addition, experiments have been made directed toward replacing the man at the linotype keyboard with a photoelectric cell scanner which would "read" from specially prepared copy produced by a typewriter with special characters.[40] This would eliminate the printer from the linotype machine in the same way that the reperforator and the Multiplex-Simplex repeater are eliminating operators from the teletype.

The ultimate development would be the introduction of a photographic method of printing. If use were made of paper sensitive to some type of cathode-ray in which the photo-chemical action set up would not require development of any kind, type could be replaced by a negative. This development awaits only the invention of an adequate method of preparing the negative and an inexpensive sensitizer. This method is somewhat similar to offset photography which has been found relatively inexpensive in making reprints of books when the books are printed from type and not from plates. In emergencies newspapers and periodicals have been composed of plates for each page made by photo-engraving.[41] If the photo-engraving process were to replace printing as the facsimile machine threatens to replace the teletype system, labor in the printing trades would be almost completely eliminated.

At the turn of the century window glass was produced almost entirely by hand craftsmanship. Five classes of skilled workers (gatherers, blowers, snappers, flatteners, and cutters) were necessary to fashion the molten glass into a sheet. The cylinder machine, a mechanical window-glass blower, followed the hand method of blowing a long, cylindrical bubble of glass which, when cooled, was split open and flattened. It eliminated the highly skilled blower and gatherer and the semi-skilled snapper. From its introduction around 1900 to its replacement by a still better technique in 1913–14, the cylinder machine caused a decrease of 56 percent in the amount of window glass produced by the hand process. Although the improvements made in the cylinder machine during this period did not increase the number of skills eliminated, they raised the productive efficiency of the workers retained, so that less and less labor was required to produce a given amount of window glass.

But while the facsimile machine in telegraphy and photo-engraving in printing merely foretell almost laborless methods, the sheet process in window glass manufacture has practically achieved that result. In that process, a flat sheet of glass is drawn directly from a fore-hearth connected by a cooling tank with the melting tank, thereby eliminating the splitting and flattening of the cylinder. The sheet process thus displaced a fourth craft, leaving only one skilled trade—cutting—as an essential process. With the adoption of the sheet method, the culmination of the third pattern of skill-displacement was definitely achieved.[42]

All new techniques, however, do not result in a reduction or elimination of skill requirements. In certain cases new techniques cause the

[40] Raymond F. Yates, Machines Over Men, Frederick A. Stokes Co., New York, 1939, p. 221.
[41] Ibid., p. 223.
[42] See Jerome, op. cit., pp. 97–102.

replacement of a large number of semi- or unskilled workers by a few highly skilled operators.

For example, the warp tying-in machine used in cotton weaving enables a skilled machine operator, with an assistant, to do work formerly requiring 12 to 18 tying-in girls. Their work required considerable adeptness and experience, but not a degree of skill comparable with that required of the machine operator.[43]

A steam-shovel operator is likewise more skilled than the ditch-diggers he replaces.

The tendency toward the creation of new skills is important, but even though a new skill is created by a new technique, unit labor requirements in the process as a whole are generally reduced. Furthermore, producers sooner or later tend to develop new mechanisms which eliminate the new skill or standardize its operation, so that the function can be performed by a semi- or unskilled worker.

SKILLED WORKERS AS A PROPORTION OF ALL WORKERS

Whether the proportion which skilled workers constitute of the Nation's labor force is increasing or declining appears impossible of absolute determination with existent data. Since 1936 the Bureau of Labor Statistics in its wage and hour studies of specific industries has classified employees as to whether they are skilled, semi-skilled or unskilled. But the period 1936 to date is too short for determining occupational trends.

By using the social-economic groupings made by Dr. Alba Edwards of the Bureau of the Census, it is possible to compute the proportion of all workers designated by him as skilled in 1910 and to compare that proportion with the percentage so designated for 1930 in manufacturing and mechanical industries. Several considerations as to the use of this method must, however, be borne in mind:

(1) Concerning the basic problem of the standard used in the determination of skill, Dr. Edwards states:

* * * The term skill, for the purposes of a grouping such as here presented. is considered properly applied only to those occupations for which the expenditure of muscular force is one of the chief characteristics. Within this field, those occupations have been considered skilled for the pursuance of which a long period of training or an apprenticeship usually is necessary, and which in their pursuance call for a degree of judgment and manual dexterity, one or both, above that required in semiskilled occupations. Those occupations have been considered semiskilled for the pursuance of which only a short period or no period of preliminary training is necessary, and which in their pursuance call for only a moderate degree of judgment or of manual dexterity.[44]

The number of borderline cases between skilled and semiskilled classes undoubtedly bulks extremely large because Dr. Edwards undertook to classify all gainful workers in the United States into only 9 groups, of which the grouping by skill was one. It is hardly necessary to point out the tremendous difficulties of grouping millions of gainful workers into so small a number of classes. As Dr. Edwards states, "Each of the groups doubtless includes some workers who properly belong in another group, and from each group doubtless are omitted some workers who properly belong there."[45]

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[43] Jerome, op. cit., p. 398.

[44] Quarterly Publications of the American Statistical Association, vol. XV, June 1917, "Social-Economic Groups of the United States," by Alba M. Edwards, p. 646.

[45] Ibid., p. 645.

(2) The manufacturing and mechanical industries of 1930 include a number which were non-existent in 1910. In fact, the pattern of the economy has been greatly changed by the various shifts in the relative importance of particular segments.

(3) Designations of certain occupations may remain constant while actual functions performed by the workers engaged therein may be entirely changed. Many workers today are designated by terms which, because of changing processes, no longer indicate the high degree of skill formerly connoted by such terms.

(4) In the 1930 tabulation foremen were included with skilled workers, but in 1910 they were omitted from that group. This would obviously reduce the possibility of a decline in the proportion of skilled workers.

On the other hand, both the 1910 and 1930 groupings are those of the same student, and thus reflect a relatively constant opinion concerning the standards underlying the classification. Pending more detailed analyses, however, it is impossible to determine with any degree of precision whether or not the skill-displacing tendencies of technology have been offset by the creation of new skills.

According to Dr. Edwards' data, employment in manufacturing and mechanical industries in 1910 amounted to 10,658,881, of whom 3,821,327, or 35.9 percent, were classed as skilled workers.[46] In 1930 the number employed in manufacturing and mechanical industries totaled 14,332,372, of whom 4,678,766, or 32.6 percent, were designated as skilled.[47] This decline between 1910 and 1930 in the proportion which skilled workers constitute of the total labor force in manufacturing and mechanical industries may represent the actual net change in occupational groupings. The tendency appears to be toward "downgrading" rather than "upgrading," and is substantiated by numerous specific cases in which technology has reduced the amount of skill required in the performance of a given function.

PRESENT TRENDS IN OCCUPATIONAL REQUIREMENTS

In 1931 a study was made of prevailing industrial conditions and mechanical operations performed under the auspices of the Employment Stabilization Research Institute of the University of Minnesota.[48] In 1936 a similar analysis was made, its point of departure being likewise the strictly mechanical aspect of industrial processes.[49] The 1936 study also compared the characteristics of the personnel employed, the work performed, and the machinery utilized for the processes studied in the 2 years.

One of the best methods of ascertaining changes in skill requirements is to compare the amount of time required for training at different periods. This method does not depend upon subjective evaluation of skill involved by either the analyst or the investi-

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[46] Ibid., p. 648.

[47] U. S. Bureau of the Census, A Social-Economic Grouping of the Gainful Workers of the United States, 1938. The great decline in the number of unskilled farm workers during this period distorts any comparison which endeavors to include workers in all fields.

[48] Charles A. Koepke, A Job Analysis of Manufacturing Plants in Minnesota (Univ. Minn. Employment Stabilization Res. Inst. Bull., vol. II, No. 8, June 1934).

[49] Work Projects Administration, National Research Project. Changes in Machinery and Job Requirements in Minnesota Manufacturing, 1931–36, by C. A. Koepke and S. T. Woal, 1939.

gator. Its only qualification is that it rests upon the reasonable assumption that under normal conditions a decrease in the length of the training period generally indicates a decrease in the amount of skill required.

The changes in the length of training periods required for all production workers in 1931 and 1936 in five diversified industries—metal working, baking (hand-operated), creamery, printing (engraving), and laundry—are shown in chart IX, table 12. The tendency in each of the industries, whether highly mechanized or hand-operated, was definitely toward a shorter training period for a greater proportion of workers.

TABLE 12.—*Length of training period required, 1931 and 1936* [1]

PRODUCTION WORKERS IN MINNESOTA MANUFACTURING

Industry	Less than ½ month		½ to 2 months		3 to 9 months		10 months to 2 years		2 years to 4 years		Over 4 years	
	1931	1936	1931	1936	1931	1936	1931	1936	1931	1936	1931	1936
Metalworking	4	20	22	30	11	16	20	23	42	7	1	4
Baking (hand-operated)	8	45	15	27	15	16	30	7	32	5	0	0
Creamery	44	43	13	19	0	20	37	12	4	0	2	6
Printing (engraving) [2]	6	14	2	11	6	6	9	6	32	28	45	35
Laundry	20	39	38	43	32	9	9	9	1	0	0	0

[1] Based on identical plants in industries in which 85 or more workers were surveyed in the given year.
[2] Includes high-class printing and newspaper printing.

Source: Work Projects Administration, National Research Project, Changes in Machinery and Job Requirements in Minnesota Manufacturing, 1931–36, by C. A. Koepke and S. T. Woal, 1939, p. 38.

In metalworking only 4 percent of the production workers in 1931 required a training period of less than half a month; by 1936 that proportion had risen to 20 percent. On the other hand, the proportion of workers which required from 2 to 4 years of training fell from 42 percent of the total in 1931 to only 7 percent in 1936. This was due to the use of jigs, fixtures, and other devices which reduced the degree of skill and therefore the amount of training required for many jobs.[50]

The same tendency was apparent in a less mechanized industry—hand-operated bakeries. The proportion of workers requiring less than one-half month's training rose from 8 to 45 percent in the same period, while the proportion requiring 2 to 4 years' training fell from 32 to 5 percent. This curtailment of the training period is due largely to the further division of labor and to more efficient management. In some hand-operated bakeries, where formerly one baker had made a complete product, a type of assembly line, with each worker performing one simple operation was introduced. This is a striking illustration of the use of chain work to save labor.

Similarly, in printing the proportion of workers requiring a training period of less than one-half month rose from 6 to 14 percent and those requiring one-half to 2 months increased from 2 to 11 percent. On the other hand, the proportion requiring 2 to 4 years of training fell from 32 to 28 percent, and those requiring over 4 years dropped from 45 to

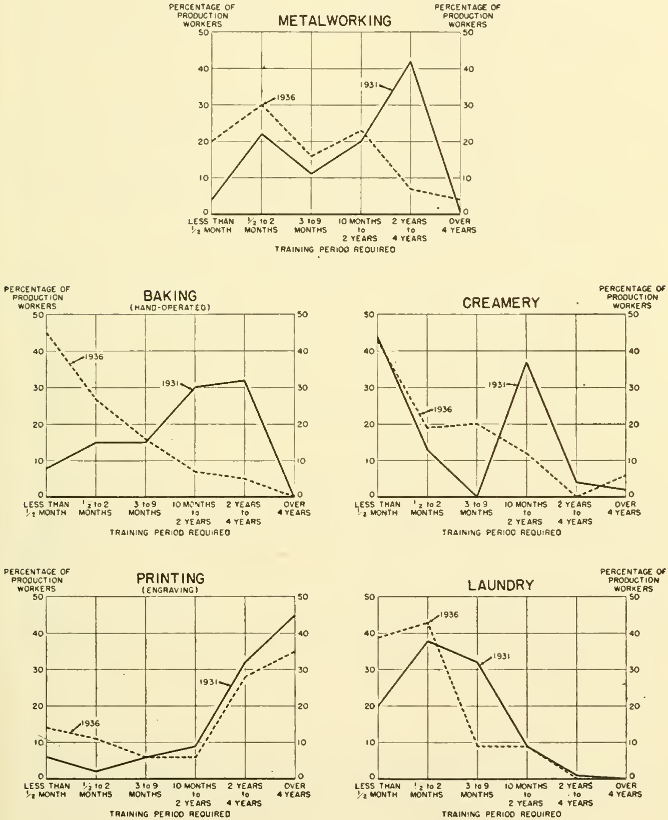
[50] During the period 1931–36 a number of the plants studied set up industrial engineering departments composed of men trained in production methods and factory management who determined how manufacturing costs might be lowered. In one plant surveyed they designed new equipment, improved production techniques, arranged machine lay-outs more effectively, and eliminated considerable waste of materials.

Chart IX

CHANGE IN LENGTH OF TRAINING PERIOD REQUIRED*

PRODUCTION WORKERS IN MINNESOTA MANUFACTURING

1931 AND 1936



* Based on identical plants in industries in which 85 or more workers were surveyed in the given year.

Source: Table 12.

35 percent. This decline in the need for extensive training was due to the installation of automatic and semiautomatic equipment.

The authors of the study make this observation:

In the printing industry, operations on automatic machinery rose from 25 percent in 1931 to 45 percent in 1936, while those on semiautomatic machines also increased slightly. * * * The increase of automatic operations in the baking industry, from 12 percent in 1931 to 40 percent in 1936, reflects the technological trend in the mechanized bakeries. Many of the operations previously assigned to hand labor, such as rolling dough and forming loaves of bread, had by 1936 been transferred to machines. Similarly the new equipment on which operations were observed in the paint industry was automatic, sometimes representing a shift from manual operations and sometimes, as in the case of the grinder, introducing a striking increase in capacity.

In the laundry industry considerable savings were effected "in labor and in skills by the introduction of more speedy air-driers and of semiautomatic shirt pressers." [52]

It appears that the tendency of technology to reduce skill requirements has not been reversed.

In several of the plants covered * * *, the installation of automatic machines in large numbers or the rendering of old machines automatic or semiautomatic by the application of special fixtures has resulted in a corresponding revision of the entire process of production. Skilled labor has been reduced and in some cases virtually eliminated, and training periods for many semiskilled operations have been cut down. Thus, although a small group of highly skilled "machine setters" is always required to set up and adjust the equipment, in actual production semiskilled workers tend to predominate.[51]

While certain skilled workers will always be required to set designs, etc., they are giving way in the labor force to workers of lower skill. But the number of completely unskilled workers also appears to be declining. One of the most spectacular changes between 1931–36 noted by this study was the decline in the proportion which completely unskilled workers were of the total number of production workers. In 1931 virtually all the industries covered had some production workers so classified; in 1936 the proportion had dropped in the majority of industries surveyed, and in several plants this type of job had disappeared altogether.

The *ease* with which techniques of production can be devised to replace unskilled workers and the *importance* from the cost standpoint of developing techniques to replace the most-skilled workers combine to reduce the proportion of most-skilled and least-skilled workers with a corresponding gain in the semi-skilled. The authors of the Minnesota study found that—

Few of the plants resurveyed had many class A (the most-skilled) jobs, whereas in every industry the plants had a substantial proportion of jobs in classes C and D (the semi-skilled); these had increased at the expense of occupations in classes A or E (the least-skilled) in most cases.[53]

In the opinion of the authors, the use of skilled workers is still declining.

The data presented here tend to support the contention put forward in the 1931 study that advances in production technique have not only drastically cut down the time necessary for training but have also given rise to significant changes in the qualifications demanded of the worker. There is a strong indication, more-

[51] Work Projects Administration, National Research Project, Changes in Machinery and Job Requirements in Minnesota Manufacturing, 1931–36, 1939, p. 11.
[52] Ibid., pp. 13–14.
[53] Ibid., p. 43.

over, that the process of increasing division of labor through increased mechanization is still running its course. That course may not now be so rapid or so revolutionary as before, but it is still causing important developments in industry and is showing a tendency to continue in that direction.[54]

TECHNOLOGY AND LABOR'S DEMAND FOR GOODS

If reductions in prices are not made to offset lower unit labor requirements and skill-displacement, technology will tend to reduce labor's share of the value of products. When the amount of labor required per unit of goods is reduced, the wage payment per unit will decline unless average earnings increase to an extent greater than the advance in labor productivity. Furthermore, if unit labor requirements are materially decreased, a labor surplus will develop unless production is markedly advanced, and the mere existence of a labor surplus is a depressant upon wage rates. In addition, if the quality of work (the degree of skill) required per unit of goods declines, wage payments per unit will tend to decline.[55]

If the prices of goods remain constant while unit labor costs decline, labor will receive a diminished share of the value of products. Then recipients other than labor will receive an increasing share. The other recipients fall largely into the upper-income or propertied classes which save a much larger proportion of their income than does labor. Thus, technology by reducing unit labor costs may aggravate the existent disproportion between consumption and savings.

The consumption-saving problem has been well described by Lauchlin Currie.

> When * * * a part of the wages received or of money realized for sales is not disbursed but is retained by the individual either in the form of cash or of deposits, or is used to pay off debts, or even if it is invested in securities, there may be an interruption in the flow of the money stream. Whether there is or is not depends on whether the money thus withdrawn is kept idle, or hoarded, or whether it is returned to the stream through disbursement for new plant and equipment, or for renovation or enlargement of existing plant, or offset by the expenditure of an equal amount. The money thus restored continues to be a saving by the individual, but it is no longer a withdrawal from the income stream. * * *
>
> It is obvious that the larger the portion of a given national income that is withheld from consumption, the larger must be the expenditures that represent offsets to saving, if the national income is not to decline. To state the reverse of this proposition, the larger the portion of income that is spent on consumption, the smaller need be the volume of capital expenditures to sustain the given national income.[56]

The behavior of unit labor costs depends upon two factors: Average hourly earnings and output per-man-hour. If the wage cost per hour (average hourly earnings) advances more than the amount of goods produced per hour (output per man-hour), unit labor costs will rise. On the other hand, if the increase in output per man-hour exceeds the rise in average hourly earnings, unit labor costs will fall.[57]

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[54] Ibid., pp. 36–37.

[55] "The breaking down of jobs and operations into their elements often results in greater division of labor, which also weakens skill. Every loss in skill, of course, means a weakening of the bargaining power of labor." (Carroll Daugherty, Labor Problems in American Industry, Houghton Mifflin, Boston, revised edition, 1938, p. 592.)

[56] Hearings before the Temporary National Economic Committee, Savings and Investment, Pt. 9, 1940, pp. 3521–3522.

[57] There are two methods of computing indexes of unit labor costs, both of which should theoretically give the same result. The index of unit labor costs may be derived either by dividing the index of pay rolls by the index of production or by dividing the index of average hourly earnings by that of output per man-hour. Since average hourly

Indexes of production are available from the National Research Project study, Production, Employment, and Productivity in Fifty-nine Manufacturing Industries, 1919–1936. For 24 industries, or groups of industries (which were responsible in 1929 for 71 percent of the total number of employees covered by the National Research Project study), it is possible to obtain comparable indexes of pay rolls.[58] By limiting the comparison to the Census of Manufacturers years, 1923 and 1935, comparability of the two series is assured.

Average hourly earnings from 1923–35 are available from the National Industrial Conference Board for 11 of the 24 industries. Although in certain cases industry designations are somewhat dissimilar, such as "rubber products" (Bureau of Labor Statistics and National Research Project) and "rubber manufacturing" (National Industrial Conference Board), the basic production operations covered are essentially the same.

That the advance in hourly earnings did not keep pace during this period with the increase in output per man-hour is shown clearly by chart X, table 13.

TABLE 13.—*Percent change in hourly earnings, output per man-hour, and unit labor cost in 11 manufacturing industries, 1923 to 1935*

Industry	Percent change from 1923 to 1935 in—		
	Average hourly earnings	Output per man-hour	Unit labor cost
Iron and steel	+9.9	+48.2	−20.0
Chemicals	+19.8	+74.2	−29.5
Rubber products	+28.0	+79.6	−32.2
Paper and pulp	+5.8	+46.5	−30.0
Paints and varnishes	+7.7	+31.7	−15.5
Boots and shoes	+15.2	+54.1	−38.8
Leather	+14.2	+38.9	−20.6
Cotton goods	+.7	+28.5	−22.4
Woolen and worsted goods	+2.2	+43.7	−26.3
Knit goods	+36.1	+66.2	−21.9
Newspapers and periodicals	+24.4	+45.8	−20.1

Source: Hourly Earnings, National Industrial Conference Board, Wages, Hours, and Employment in the United States, 1914–36; Output per Man-Hour, National Research Project, Production, Employment, and Productivity in Fifty-nine Manufacturing Industries, 1919–36, pt. II; Unit Labor Cost, U. S. Bureau of Labor Statistics, Monthly Labor Review, December 1939, "Employment and Production in Manufacturing Industries, 1929 to 1936," p. 1404.

In each of the industries the increase in output per man-hour was far greater than the advance in hourly earnings. Consequently, unit labor costs in each were materially lower in the latter than in the former year. Interestingly enough, those industries in which average hourly earnings advanced most noticeably—knit goods (36.1 percent), rubber products

earnings are derived by dividing pay rolls by man-hours, and since the index of output per man-hour is derived by dividing the index of production by that of man-hours, the factor, man-hours, is thus common to both average hourly earnings and output per man-hour. Dividing average hourly earnings by output per man per man-hour is equivalent to dividing the index of pay rolls by that of production, which is the first method cited. Actually, however, there is a difference in results, in that average hourly earnings are computed by the National Industrial Conference Board and the Bureau of Labor Statistics from man-hour and pay-roll samples which are not adjusted for aggregates, whereas the index of pay rolls, published by the Bureau of Labor Statistics, used with the index of production, is computed from a larger sample by the chain index method to represent changes in aggregate pay rolls. Therefore this latter method is used herein.

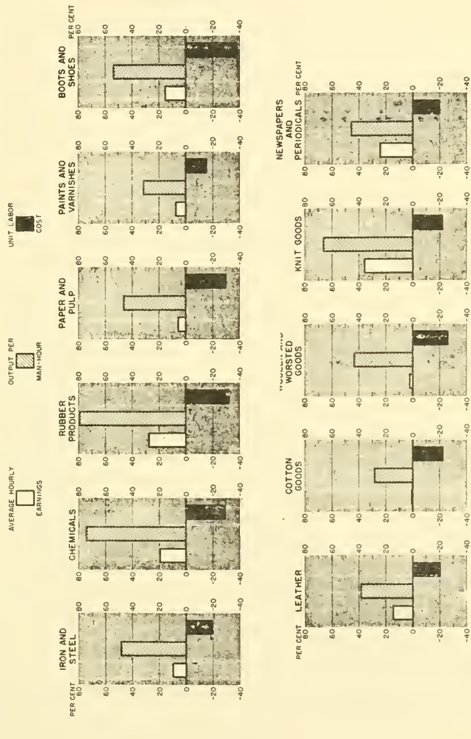
[58] U. S. Bureau of Labor Statistics, Monthly Labor Review, December 1939, pp. 1403–1404.

(28.0 percent), newspapers and periodicals (24.4 percent)—were characterized by some of the most extensive increases in output per man-hour (66.2, 79.6, and 45.8 percent, respectively). Regardless of whether increased hourly earnings made it necessary for producers to increase greatly the productivity of the labor force or whether the increase in output per man-hour made it possible for producers to pay higher hourly wages, the important fact is that unit labor costs did decline.

CHART X

PER CENT CHANGE IN HOURLY EARNINGS, OUTPUT PER MAN-HOUR AND UNIT LABOR COST, 1923-1935

11 MANUFACTURING INDUSTRIES



SOURCES: Hourly Earnings, National Industrial Conference Board, WAGES, HOURS, AND EMPLOYMENT IN THE UNITED STATES, 1914-1936
Output per Man-Hour, National Research Project, PRODUCTION, EMPLOYMENT, AND PRODUCTIVITY IN 59 MANUFACTURING INDUSTRIES, 1919-1936, Part II, 1939
Unit Labor Cost, Bureau of Labor Statistics, MONTHLY LABOR REVIEW, December 1939, p 1404

This decrease was less than 20 percent in only one of the 11 industries—paints and varnishes. It should be noted that this comparison stops short of very recent years in which advances in hourly earnings took place caused by legislation such as the National Industrial Recovery Act, the Wages and Hours Act, the Fair Labor Standards Act, and the National Labor Relations Act, and by accompanying marked growth in union organization.

A comparison of changes in hourly earnings, output per man-hour, and unit labor costs in the short but dynamic period of 1935–39 can be made for 13 diversified industries (table 14).

TABLE 14.—*Percent change in hourly earnings, output per man-hour, and unit labor cost in 13 manufacturing industries, 1935 to 1939*

Industry	Percent change from 1935 to 1939 in—		
	Average hourly earnings	Output per man-hour	Unit labor cost
Iron and steel	+27.0	+27.5	−0.4
Petroleum refining	+21.6	+26.0	−3.5
Chemicals	+23.1	+11.5	+10.4
Paints and varnishes	+20.1	+10.5	+8.8
Rayon	+25.7	+58.1	−20.5
Cement	+22.2	+25.2	−2.4
Cotton goods	+3.5	+20.9	−14.4
Boots and shoes	−1.8	+6.9	−8.1
Paper and pulp	+17.2	+17.3	−.1
Newspapers and periodicals	+12.6	+3.9	+8.4
Bread and other bakery products	+16.3	+13.9	+2.1
Flour	+10.4	+7.2	+3.0
Cane-sugar refining	+12.0	−3.8	+16.4

Source: U. S. Bureau of Labor Statistics, Monthly Labor Review, July 1940, p. 36.

During this short span of years the marked increases in hourly earnings were generally matched or even exceeded by increases in output per man-hour. In only five of the industries was the increase in hourly earnings greater than in output per man-hour. And in two of these five, unit labor costs rose only 3.0 and 2.1 percent, each. In the rest (except cane-sugar refining wherein labor productivity declined) the advance in output per man-hour exceeded the increase in hourly earnings. In four of the six industries with wage increases exceeding 20 percent, still greater increases in output per man-hour were achieved and lower unit labor costs resulted.[59]

It is thus apparent that even during the period of the most dynamic upward movements in hourly earnings, the increase in output per man-hour nearly matched (‶ ‶out of 13) or exceeded (7 out of 13) the rise in hourly earnings, resulting in stability or decreases in unit labor costs. The foregoing comparison casts considerable light on the effect of technology upon wage costs in relation to output. But to obtain a more inclusive picture, it is desirable to extend the analysis of unit labor costs over a longer period of time. It has been possible to extend the production indexes for 20 industries, using the same sources and methods as the National Research Project to later years than the published termination period of most of their indexes, 1935–36.[60]

Production indexes for 1938 were obtained for 18 and indexes for 1939 were obtained for 13 of the 20 industries. Comparable pay-roll series were available for all 20. For 17 industries comparable data for the year 1919 were available and unit labor cost series were computed. The trend in unit labor costs for each of these industries evidenced by behavior in the selected years of 1919, 1923, 1929, 1933, 1935, 1936, 1937, 1938, 1939 is shown in chart XI, table 15.

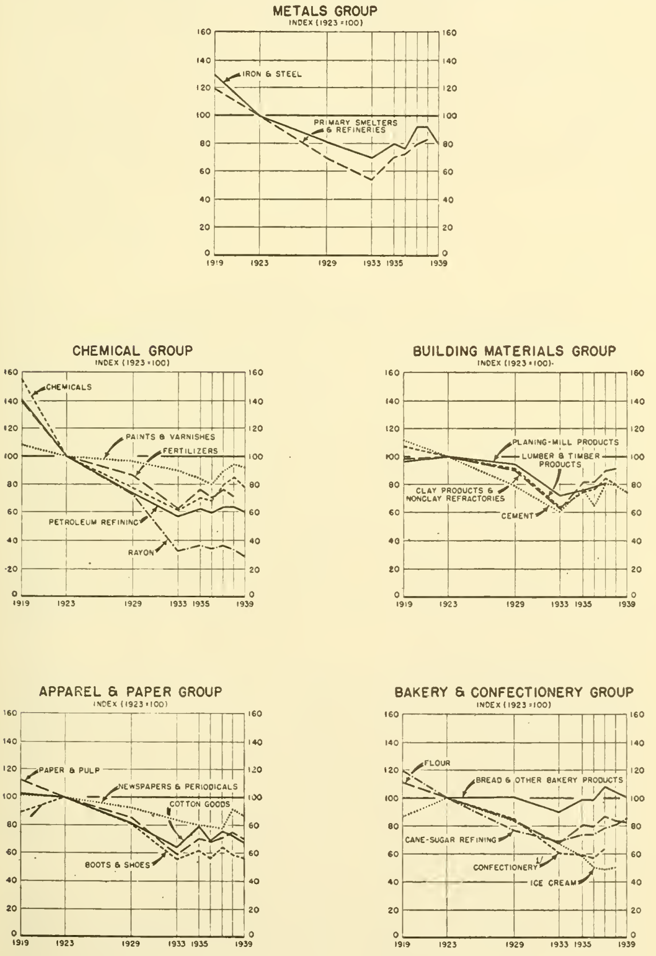
[59] While unit labor costs may be influenced not only by the use of labor-saving techniques but also by the rate of operation, a decline in unit labor costs affects the consumption-saving problem regardless of its cause.

[60] Original use of the National Research Project indexes and the Bureau of Labor Statistics pay roll indexes for the purpose of estimating changes in unit labor cost was made by the U. S. Bureau of Labor Statistics, and he unit labor cost figures thus derived were published in the December 1939 issue of the Monthly Labor Review under the title "Employment and production in Manufacturing Industries, 1919–36," pp. 1397–1404. The projection of the National Research Project indexes of production forward to 1939 and their use with pay-roll indexes for the years 1919–33 and 1936–39 in the computation of unit labor cost were by Victor Perlo, U. S. Department of Commerce, and Witt Bowden, U. S. Bureau of Labor Statistics; the figures thus derived were published in the July 1940 issue of the Monthly Labor Review, p. 33, under the title "Unit Labor Cost in 20 Manufacturing Industries, 1919–39."

Chart XI

UNIT LABOR COST IN 20 MANUFACTURING INDUSTRIES

SELECTED YEARS, UNITED STATES, 1919-1939



1/ CONFECTIONERY 1925=100

Source: Table 15.

TABLE 15.—*Indexes of unit labor cost in 20 manufacturing industries, 1919–39*

[1923=100]

Industry	1919	1923	1929	1933	1935	1936	1937	1938	1939
Blast furnaces, steel works, and rolling mills	129.2	100.0	81.8	69.3	79.9	76.6	91.5	91.3	79.6
Nonferrous metals: Primary smelters and refineries	119.1	100.0	70.5	54.1	69.5	72.6	79.5	83.2	[1]
Petroleum refining	140.7	100.0	73.0	57.5	62.2	59.7	64.5	64.6	60.0
Chemicals	156.1	100.0	77.7	61.2	70.5	68.6	79.8	85.3	77.8
Fertilizers	140.3	100.0	86.5	61.9	76.0	70.4	75.9	71.4	[1]
Paints and varnishes	108.5	100.0	96.7	90.2	84.6	79.9	90.0	94.7	92.0
Rayon	[1]	100.0	72.4	32.8	36.8	34.6	36.4	34.0	29.3
Planing-mill products	96.6	100.0	94.3	71.5	75.4	[1]	80.3	[1]	[1]
Lumber and timber products	107.2	100.0	90.8	64.0	74.2	76.7	84.5	80.2	[1]
Clay products (other than pottery) and nonclay refractories	98.3	100.0	90.1	63.2	81.1	81.3	89.5	91.0	[1]
Cement	111.3	100.0	79.3	60.5	76.1	64.9	80.4	79.6	74.4
Cotton goods	102.5	100.0	81.5	64.1	79.3	68.9	75.2	72.8	67.8
Boots and shoes	89.3	100.0	81.3	55.3	61.3	56.0	63.6	58.7	56.3
Paper and pulp	112.2	100.0	85.5	58.9	70.0	68.1	70.7	74.6	69.9
Newspapers and periodicals	101.5	100.0	92.2	83.8	79.9	79.4	77.4	91.3	86.7
Bread and other bakery products	[1]	100.0	100.2	89.9	99.0	98.7	108.0	104.5	101.0
Confectionery	[1]	[2] 100.0	85.2	60.6	59.7	57.2	63.1	[1]	[1]
Flour	110.9	100.0	85.0	67.2	80.2	79.2	86.4	83.4	82.6
Ice cream	86.6	100.0	83.7	67.2	58.3	50.2	49.2	50.4	[1]
Cane-sugar refining	119.3	100.0	77.1	68.7	73.2	73.5	78.2	80.7	85.2

[1] Not available.
[2] 1925.

Source: Victor Perlo and Witt Bowden, "Unit Labor Cost in Twenty Manufacturing Industries, 1919 to 1939," U. S. Bureau of Labor Statistics, Monthly Labor Review, July 1940, p. 34.

It is evident that the long-term trend in unit labor costs has been definitely downward. The downward trend was very noticeable up to 1933 in both iron and steel and primary smelters and refineries. The depression declines in production of these industries were probably the major cause of the increase in unit labor costs during 1933–35. Subsequent higher wage rates undoubtedly were the prime factor in the further advance. But in 1939 unit labor costs in iron and steel fell well below the 1937 level and even below the 1929 level upon the attainment of a fairly high rate of production—the production index being 9 percent below 1929 and 1937 levels.

In primary smelters and refineries, unit labor cost data are not yet available for 1939. The great curtailment of production in this industry since the depression, accompanied by recent advances in wage rates, is doubtless responsible for the upward trend in unit labor costs since 1933.

In the chemical group, the most pronounced decline in unit labor costs took place in the rayon industry, and the least pronounced in paints and varnishes. Despite recent increases in hourly earnings in these industries, unit labor costs in 1938 were below the 1929 level in petroleum refining, fertilizers, paints and varnishes, and rayon. Only in chemicals were these costs higher in 1938 than in 1929, but by 1939 they were again down to the 1929 level.

Unit labor costs in the building materials group followed a similar pattern, with a gradual decline to 1929, a marked fall from 1929–33, and gradual increases thereafter—increases in large part due to the lack of recovery in production of these industries.

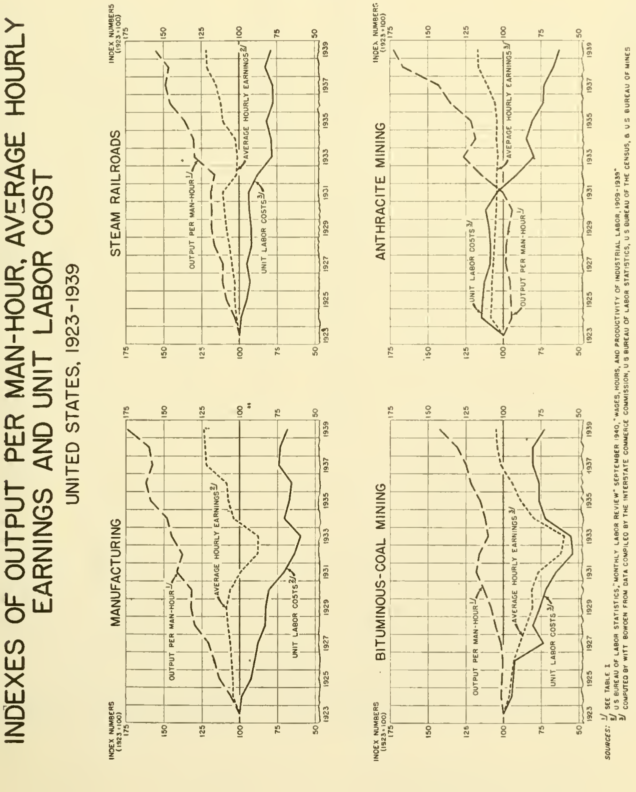
In the apparel and paper group, unit labor costs fell similarly between 1923 and 1933 in paper and pulp, cotton goods, and boots and shoes. After 1933 these three showed minor increases, but boots and shoes and cotton goods turned downward in 1938, and paper and pulp in 1939. Newspapers and periodicals declined all through the

period up to 1938 when they increased abruptly, again turning downward in 1939.

The industries in the baking and confectionery group showed diversified trends over the long-term period, with ice cream and confectionery at one extreme falling to a low level, and bread and other bakery products at the other extreme remaining comparatively stable. The trend after 1935 in flour follows the general pattern of a slight decrease in 1936, an increase in 1937, and a decline thereafter. But in cane-sugar refining the decline toward the end of the period does not occur; in 1939 the series was still climbing. This may be due in part to production being lower in 1939 than the 1935–38 levels.

The general tendency, reflected in the behavior of unit labor costs in these specific industries, for increases in output per man-hour to exceed those in average hourly earnings is indicated also by the indexes for the broad fields of manufacturing as a whole, steam railroads, bituminous coal, and anthracite mining.

Chart XII



In each, a scissors-like divergence took place; in each output per man-hour evidenced a greater long-term increase than average hourly earnings with the result that the secular trend in unit labor costs is downward. This is apparent over the long-term period 1923–39 in chart XII, table 16.[61]

TABLE 16.—*Indexes of output per man-hour, average hourly earnings, and unit labor cost, 1923–39*

[1923=100]

Year	Output per man-hour	Average hourly earnings	Unit labor cost	Output per man-hour	Average hourly earnings	Unit labor cost
	Manufacturing			Steam railroads		
1923	[1] 100.0	[2] 100.0	[3] 100.0	[1] 100.0	[2] 100.0	[3] 100.0
1924	105.8	104.7	98.9	103.0	101.8	99.0
1925	113.2	104.5	92.2	108.5	103.0	95.1
1926	116.9	105.4	90.0	111.1	103.0	92.9
1927	120.8	106.1	87.8	110.8	105.0	94.8
1928	129.5	107.6	83.0	116.3	106.3	91.6
1929	131.9	108.8	82.5	118.2	108.4	91.9
1930	131.6	106.1	80.7	118.0	109.8	93.0
1931	141.3	99.4	70.3	118.8	110.8	93.3
1932	137.7	88.0	63.9	116.1	101.7	87.8
1933	144.8	87.4	59.6	129.3	101.0	78.2
1934	147.9	104.0	70.3	130.1	102.3	78.7
1935	158.8	107.4	66.9	135.9	110.7	81.6
1936	161.8	108.5	65.4	145.7	112.0	77.1
1937	157.5	121.9	74.0	148.5	115.1	77.6
1938	159.8	122.8	73.1	146.8	121.1	82.7
1939	174.5	123.8	68.1	154.9	121.6	78.6
	Bituminous-coal mining			Anthracite mining		
1923	[1] 100.0	[2] 300.0	[3] 100.0	[1] 100.0	[2] 100.0	[3] 100.0
1924	101.7	96.2	94.6	94.4	108.3	114.7
1925	101.0	94.7	93.7	94.9	107.7	113.7
1926	100.3	93.0	92.8	95.4	107.3	112.5
1927	101.6	88.9	73.2	98.3	106.6	108.6
1928	105.3	84.8	80.5	98.1	106.0	108.2
1929	108.1	80.6	75.6	96.4	105.4	109.4
1930	112.8	81.1	71.9	94.0	104.8	111.1
1931	118.0	76.6	64.8	100.2	104.2	104.8
1932	115.9	61.6	54.0	115.0	104.3	90.8
1933	110.0	59.3	55.1	126.4	103.5	79.8
1934	111.9	79.5	72.2	118.5	104.4	84.7
1935	115.4	88.2	76.2	121.3	104.1	80.7
1936	121.5	94.0	76.2	135.1	105.4	73.3
1937	124.8	101.4	80.4	142.8	110.4	72.9
1938	130.4	104.0	80.3	166.1	116.5	66.9
1939	142.1	104.8	72.5	172.6	116.8	62.7

[1] See table 1.
[2] U. S. Bureau of Labor Statistics, "Wages, Hours, and Productivity of Industrial Labor, 1909 to 1939," September 1940.
[3] Computed by Witt Bowden of the U. S. Bureau of Labor Statistics from data compiled by the Interstate Commerce Commission, U. S. Bureau of Labor Statistics, U. S. Bureau of the Census, and U. S. Bureau of Mines.

Despite substantial advances in hourly earnings during the latter part of the thirties, labor productivity increased to such an extent that unit labor costs in 1939 were at an all-time low in anthracite mining and were almost down to the previous all-time low in steam railroads. In manufacturing, unit labor costs dropped in 1939 to a level exceeded only by the lows of 1932–33 and 1935–36 when hourly earnings were materially less than in 1939.

The increase in average hourly earnings during the latter part of the thirties represented in each case a striking departure from the

[61] These series on unit labor costs for these four broad fields represent indexes compiled by Witt Bowden, of the U. S. Bureau of Labor Statistics, from data supplied by the agencies cited in the table and chart.

long-term trend. As is well-known, a combination of factors, including the enactment of labor legislation validated by the Supreme Court, were largely responsible for this sudden upturn in wages. Since it is unlikely that this combination of factors will recur in the near future, a levelling off in the rate of increase in hourly earnings may be expected. No such behavior in the rate of increase in labor productivity is anywhere indicated; on the contrary, even more rapid advances in output per man-hour are likely.

This possible widening of the spread between labor productivity and hourly earnings obviously means even greater declines in unit labor costs. If prices remain constant—and in a large segment of the economy they have been markedly stable—this decline in unit labor costs will further reduce labor's share of the value of products.

TECHNOLOGY AND THE EMPLOYED WORKER

NERVOUS AND MENTAL STRAIN

The very subdivision of labor inherent in the factory method of production connotes the continual performance of standardized operations by the worker. Where technology has so transformed productive processes that the individual worker merely attends a semiautomatic machine, monotony and boredom are inevitable, and the worker who prefers the monotonous routine imposed by numerous technological processes is generally of low intelligence.[62]

In recent years technology has perhaps tended to lessen the amount of highly repetitious, standardized work, but it has accomplished this only by eliminating the human element altogether. An apparently increasing tendency is the replacement of the individual worker with completely automatic processes or multi-purpose machines which perform the necessary functions. It might be observed, for example, that the muscular cramp which Morse telegraphers acquire after years of continual tapping has largely disappeared owing to the replacement of the Morse key by the teletype system. A recent British study of machine-feeding processes states:

> It is probable * * * that many of the operatives employed on machine-feeding will continue to suffer from boredom and strain. Only certain types of individuals are able to behave as mechanically as the machine on which they work and a number certainly find such conditions almost intolerable. Perhaps the chief hope of escape lies in the possibility of complete mechanization.[63]

Monotony, in addition to stunting personality development and stifling imagination, contributes to the occurrence of industrial accidents. An example of this, one of the deleterious effects of monotony on industrial workers, is shown by the following experience of a worker in a printing shop.

> In "flat work" I very often used to daydream. The purely mechanical action of picking up a sheet of paper, and setting it against "marks" all day long, brings about a state of coma * * * Click, pick the sheet up. Bang, air

[62] Cf. Ethelbert Stewart, "Industrialization of the Feeble-Minded," U. S. Bureau of Labor Statistics, Monthly Labor Review, July 1928, pp. 7–14.

[63] Medical Research Council, Industrial Health Research Board, The Machine and the Worker, Rept. No. 82, by S. Wyatt and J. N. Langdon, 1938, p. 43.

it (make the air go under it by a flick of the wrist). Shush, bring the sheet to the "marks." Here the machine takes it. Repeat this all day long, 8 hours a day, 48 hours a week, and you may be able to visualize the effect on the mind. It was on these machines that I day-dreamed, until I had the good luck to put my hand in instead of the paper. I say good luck, because it happened to be a small machine, and I was able to brake it quickly. In fact, by taking my hand, it stopped itself. I had to have the top of one finger grafted on, and several of the bones in the hand reset. Needless to say, I never day-dream now.[64]

Monotony also may lead to actual decreases in worker productivity. A British inquiry into fatigue and boredom in repetitive work concluded:

* * * (*a*) Boredom depresses the rate of working, (*b*) workers of inferior capacity tend to work more closely to their maximum than do workers of superior capacity, and (*c*) the rate of working when learning an industrial process is reduced when the worker is bored.[65]

The report goes on to point out that monotony also affords a fertile field on which the seeds of discontent may fall:

Boredom and discontent are also closely connected with the type of work, and even slight differences between one process and another may have widely different effects on the operative. Efficiency and contentment may be increased by giving the beginner a short trial on different types of work and assigning her to the process which she likes best.[66]

Discontent often leads to a deliberate slowing-down of work in all types of employment. Machinery over whose speed and rhythm the worker has no control is liable to produce strain and tension accompanied by sullen acquiescence or even resentment. Machine-feeding of a more or less automatic kind is, therefore, likely to involve human costs which are seldom fully evaluated, but which contribute to industrial inefficiency. Among them are the definite costs of unrest, absence, ill health, accidents, etc.[67]

When technological equipment is operated at high rates of speed fatigue usually rises rapidly. Output per worker may fall so greatly as the working day progresses that productivity of the employee over the entire day may drop below the pre-speed-up level. The British Medical Research Council discovered that when machinery was operated at an abnormal rate of speed output per worker, after rising in the early part of the spell, began to fall at an extremely rapid rate until the work ceased. In one process the output in the last hour of work was 19.5 percent below the highest level recorded during the day. In the words of the report:

There can be little doubt, therefore, that fatigue was fairly severe and arose from the intensity of the work. The machines acted as pace-makers, and the operatives were impelled to work at a rate which they were unable to maintain. * * *

The results obtained in this process accordingly suggest that the discrepancy between the speed of the machines and the capacity of the operators was too great for personal comfort and efficiency, and that a slower machine speed would probably result in a higher total output and increased pleasure in work. This was found to be the case in a box-wiring process where similar conditions prevailed and a reduction in the speed of the machine caused an increase in

[64] A. Barratt Brown, The Machine and the Worker, Nicholson and Watson, London. 1934, p. 77.

[65] Medical Research Council, Industrial Health Research Board, Fatigue and Boredom in Repetitive Work, Rept. No. 77, by S. Wyatt and J. N. Langdon, London, 1937, p. 73.

[66] Idem.

[67] See P. Sargant Florence, Economics of Fatigue and Unrest, Henry Holt, New York, 1924, ch. 5.

output of 10 percent. There seems to be no justification for machine speeds which are greatly in excess of the natural rate of working of the operatives and it is difficult to understand why such speeds are set.[68]

Fatigue, like monotony, often leads to accidents. In the United States and Great Britain investigations have shown that accidents increase as wage-earners go through the working periods, rising from a low point at the beginning of the morning shift to a high point just before the noon rest period, then falling at the beginning of the afternoon only to rise again toward the end of the day. A decline just before the end of each working period is attributed to the stimulating prospect of a change from work.[69]

It is difficult to isolate the specific cause of an industrial accident. One authority has observed:

As in the case of sickness, * * * the causes of accidents are sufficiently numerous to make one wary of saying that fatigue is the directly responsible factor. There undoubtedly is a causal relationship, but fatigue does not operate alone.[70]

H. W. Heinrich, of the Travelers Insurance Co., analyzed the causes of 50,000 industrial accidents and found that mechanical hazards were responsible for only 10 percent of the mishaps. The remaining 90 percent were due to faulty instruction (30 percent), lack of concentration (22 percent), unsafe practices (14 percent), poor discipline (12 percent), inability of employee (8 percent), physical unfitness (3 percent), and mental unfitness (1 percent).[71] Fatigue was undoubtedly an element in many of the cases involving lack of concentration and perhaps in some involving unsafe practices.

Although the terms "speed-up" and "stretch-out" have been rather indiscriminately applied to practically every type of labor intensification, the former generally indicates an increase in the rapidity with which a worker must perform a given set of functions, while the latter connotes an increase in the number of functions a worker must perform within a given period of time.

Labor-intensification systems have been widely applied throughout the industrial world. There is, for example, the speed-up inherent in the application of the straight-line system of production in lieu of the bundle system in the manufacture of cotton garments. This industrial process has been described in chapter I,[72] but it deserves further consideration here because of its effect upon conditions of work.

The straight-line system makes the operator keenly aware that if she falls behind in her work, the operator next in line is rendered idle, waiting for the garment on which she is working. Unless each operation is completed promptly, the rest of the line will be delayed and the foreman will arrive to investigate the trouble.

The necessity of speed under these circumstances is obvious. The worker can no longer work at her own natural pace. She must adjust herself to the speed of her fellow workers, all of which undoubtedly results in increased individual productivity. When the workers are of a fairly uniform skill and equal tempo,

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[68] Medical Research Council, Industrial Health Research Board, Rept. No. 82, op. cit., p. 6.

[69] See P. Sargant Florence, op. cit., p. 351; Josephine Goldmark, Fatigue and Efficiency, Russell Sage Foundation, New York, 1912, p. 76; and H. M. Vernon, Industrial Fatigue and Efficiency, George Rutledge & Sons, London, 1930, ch. 6.

[70] Carroll R. Daugherty, Labor Problems in American Industry, Houghton Mifflin, Boston, 1933, p. 135.

[71] U. S. Bureau of Labor Statistics, Monthly Labor Review, "Prevention of Industrial Accidents," June 1931, p. 74.

[72] See pp. 119–120, supra.

the uniformly high speed of the work, while it may result in greater fatigue at the end of the work period, need not necessarily affect injuriously the health of the worker. But where no attention is paid to that factor, or still worse where, as a result of deliberate design, fast workers are interspersed with workers of a naturally slower tempo, the health of the worker may be seriously affected.

In one of the plants studied, management deliberately resorted to such an arrangement which caused the slower workers to strain themselves to the utmost. On the one hand, the slower worker was aware that work was piling up behind her from the fast worker on the preceding operation. On the other hand, she saw that the equally fast worker on the succeeding operation was waiting for her work. The result was a large increase in productivity by the individual workers, but at the cost of great physical and nervous strain on the part of the naturally slower workers. In the end, such an arrangement is bound to be harmful not only to the slower worker but to the efficient operation of the shop.[73]

The speed-up system may derive its tempo either from the interspersion of the more efficient workers throughout the labor force, as in the above case, or from the operation of machinery at a speed higher than the usual rate of the average worker. The latter method is particularly applicable to those machine-feeding processes in which the operator's failure to keep the machine fully supplied with material does not injure the machine or the product. In such cases the machine has often been set at a speed which equals or exceeds the highest rate attainable by the best operator, since it is believed that this increases output. An example of this procedure is cited by the British Medical Research Council.

In this process the operator was engaged in feeding a rotating dial which, when completely supplied with material, necessitated the repetition of a fairly complicated cycle of movements 37 times a minute. Six operators were observed for a period of 3 weeks and their output was recorded at hourly intervals throughout the day. * * *

The results show, in the first place, that the average efficiency was low (64.3 percent) and even in the best hour of the day it was only 68.2 percent. In this process enforced stoppages were practically negligible, therefore the low efficiency was due almost entirely to the failure of the operators to keep the machine fully supplied with material. Even the most capable worker was seldom able to keep pace with the machine for more than 10 seconds, so that the maintenance of a regular rhythm was impossible. Further, it was noticed that the operators became somewhat embarrassed and emotionally disturbed each time they failed to remove and replace the articles on the dial as it moved beyond their reach. A little time elapsed before they were able to recover their poise, and although on each occasion the effect of this disturbance on output was scarcely measurable, the total effect was appreciable.[74]

Management has usually failed to recognize that the application of speed-up and stretch-out systems may actually result in a diminution of labor productivity. Certain industries have been characterized by an almost constant intensification of the amount of work demanded from the individual employee in the belief that the greater the intensification, the higher the productivity of the individual worker. For example, in the automobile industry during the depression workers were reportedly offered bonuses to exceed the production rates established by production engineers. When these levels had been surpassed, the new rates were accepted as normal. Then intense pressure was applied for even higher records of output which in turn were regarded as normal.

With the coming of the depression the universal testimony of the auto workers is that speed-up increased beyond the powers of human endurance.[75]

[73] U. S. Bureau of Labor Statistics, Bulletin No. 662, Productivity of Labor in the Cotton-Garment Industry, by N. I. Stone, A. Cahen and S. Nelson, November 1938, pp. 55–56.

[74] Medical Research Council, Industrial Health Research Board, Rept. No. 82, op. cit., p. 5.

[75] Hearings before the Temporary National Economic Committee, Part 30, p. 1637.

In 1935 the National Recovery Administration said of the speed-up system in the automobile industry:

The only reason that it (speed-up) can exist as at present is because of the huge available supply of labor through which as one man falls by the wayside, another is there to take his place.[76]

This report went on to state:

Everywhere workers indicated that they were being forced to work harder and harder to put out more products in the same amount of time and with less workers doing the job. There was a tendency to excuse the automobile manufacturers for lack of steady work, "that is caused by market conditions." But when it comes to increasing their work loads, they (the workers) are vigorous in denouncing the management as slave-drivers and worse. If there is any one cause for conflagration in the automobile industry, it is this one.[77]

In some cases the production staff in charge of the time study department received a bonus each time they were successful in reducing the operating time of a given function. Instead of "taking honest time, * * * (they) would look and see what your record was last year and maybe boost a little more for the last model," according to the president of the United Automobile Workers in his testimony before the Temporary National Economic Committee. He continued:

* * * because the workers in automobile plant had been speeded up so much, there was a tendency on their part, when a man came around to time-study them, to try to cheat on that time study if they possibly could, and I was the same as every automobile worker, I might say.[78]

But this trick was of little avail if the time study department took as a basis in computing the worker's potential productivity not his time-study record but that of his output over a previous period, perhaps increased by a definite percentage.

The fear of unemployment resulting from the introduction of speed-up and stretch-out systems leads to discontent and, in some cases, to strikes. For example, the application of the stretch-out system in a cotton mill increased the number of automatic looms attended by an individual weaver from 35 to as many as 100 and made possible a reduction in labor costs by the use of less skilled, lower-paid workers. Even though the workers, through a fully recognized and long-established trade union, were given the right to cooperate with management in determining conditions under which the stretch-out system was to be applied, the attendant labor displacement became an increasingly acute source of dissatisfaction, leading finally to a bitter and protracted strike.

The workers on their part were dissatisfied because 350 of their number, including some permanent workers, had been eliminated, because as many more had been demoted at reduced wages, and because they soon came to believe that the new job assignments had created excessive job burdens.

The reduction in their wages "created in their minds a conviction that only by preventing further 'stretch-outs' could they preserve their security and well-being."[79]

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[76] National Recovery Administration, Division of Research and Planning, Preliminary Report on Study of Regularization of Employment and Improvement of Labor Conditions in the Automobile Industry, 1935; quoted in Hearings before the Temporary National Economic Committee, Part 30, p. 16371.

[77] Ibid., p. 16371.

[78] Hearings before the Temporary National Economic Committee, Part 30, p. 16370.

[79] The Personnel Journal, February 1934, " 'Labor Extension' in a Cotton Mill," by R. C. Nyman, Institute of Human Relations, Yale University, p. 270.

These systems of intensified labor—all designed to place the amount to be paid on a unit of production basis—have aggravated nervous strain, monotony and fatigue, increased industrial accidents, and in certain cases actually decreased productivity.[80]

PHYSICAL HARDSHIPS

Industrial accidents.

While industrial accidents, largely as a result of continuing efforts on the part of various governmental agencies, have tended to decline over a long-term period, their incidence is still sufficiently high to make them a major characteristic of modern technology. In 1937, a year of moderately intense activity, a total of 1,838,000 industrial injuries occurred throughout the United States representing 40,159 injuries per million workers.[81] The estimated number of industrial injuries in 1937 per million workers is shown by industry group and type of disability in the following table.

TABLE 17.—*Estimated number of industrial injuries per million workers, by industry group and type of disability, 1937*

Industry group	Extent of disability			
	Total	Fatal	Permanent	Temporary total
All industries	40,159	430	2,702	37,027
Agriculture [1]	24,978	416	1,247	23,315
Mining and quarrying (includes petroleum and natural gas) [2]	115,048	2,028	3,522	109,498
Construction [1]	112,230	1,048	5,877	105,305
Manufacturing [2]	36,379	236	2,772	33,371
Public utilities [2]	17,591	320	746	16,525
Trade—wholesale and retail [1]	29,407	339	3,895	25,173
Railroads [3]	34,098	680	1,190	32,228
Miscellaneous transportation [4]	36,730	755	1,887	34,088
Services and miscellaneous industries [4]	40,842	258	2,812	37,772

[1] Based on fragmentary data.
[2] Based on comprehensive survey.
[3] Based on Interstate Commerce Commission data.
[4] Based on small sample studies.

Source: M. D. Kossoris and S. Kjaer, "Industrial Injuries in the United States During 1937," U. S. Bureau of Labor Statistics, Monthly Labor Review, March 1939, p. 600.

The occurrence of industrial injuries is influenced by fluctuations in the business cycle. There exists a fairly close relationship between the trend of the frequency rate of industrial injuries, which measures the average number of injuries per million man-hours, and the volume of employment.[82] Theoretically the frequency rate should be constant regardless of the volume of employment. Actually, however, it declines rapidly on the downswing of the business cycle for the following reasons: (1) Labor forces are curtailed, with those most recently added laid off first. Skilled or semi-skilled workers with long years of service are retained by management to form a nucleus for subsequent expansion. Such workers are generally thoroughly familiar with job hazards and have developed safety habits. (2)

[80] For a discussion of the effect of these practices upon the individual worker, see Morris Cooke and Philip Murray, Organized Labor and Production, Harpers, New York, 1940, ch. 8, "Some of Management's Controversial Practices and Attitudes," pp. 94–106.
[81] Max Kossoris and Swen Kjaer, "Industrial Injuries in the United States During 1937," U. S. Bureau of Labor Statistics, Monthly Labor Review, March 1939, pp. 597–615.
[82] See Max D. Kossoris, "Industrial Injuries and the Business Cycle," U. S. Bureau of Labor Statistics, Monthly Labor Review, March 1938, pp. 579–594.

Lay-offs may lag behind operations and production in the early stages of a depression. (3) As the depression deepens, management shifts to the most efficient, modern, and also the fastest equipment. (4) Numerous injuries, which under more normal conditions would have disabled workers from 1 to 3 days, are not reported during the downswing.[83] This is only logical because, when jobs are scarce and many employees are working only part time and at reduced wage rates, a worker will endeavor not to reveal the occurrence of an injury for fear of jeopardizing his employment.

On the upswing, the frequency rate of industrial accidents increases markedly. This is probably due to the hiring of workers who are either unaccustomed to the hazards of their new jobs or whose safety habits have been dulled through lengthy lay-offs, and who, perhaps, are too eager to make a favorable showing. A study of a large petroleum concern indicates that newly added employees, as a group, suffer the majority of injuries. Only 31.8 percent of the total working force were workers with less than 3 years' service but they were responsible for 56.1 percent of all disabling accidents.[84] Also, when the employment situation is easier and hours and wage rates are more normal, workers are more inclined to report injuries and take time off, even for only 1 or 2 days.[85]

Therefore if the very existence of the business cycle causes industrial accidents to rise rapidly with the upswing and to decline during the downswing at a substantially under-reported rate, it is apparent that the close correlation between the business cycle and the reported frequency rate conceals an increase in the actual rate. Consequently, modern technology is not only the direct cause of a substantial number of industrial accidents each year; it also, as one of the major causes of business cycles, tends to raise the actual frequency rate above the level it would have held had no business cycle occurred.

Occupational Diseases.

Certain technological processes contain the danger, if not the certainty, of occupational disease. In 1933 the United States Bureau of Labor Statistics listed approximately 900 hazardous occupations, and during the period 1922 to 1933 the number of poisonous substances considered increased from 52 to 94.[86]

> The 10 years which have elapsed * * * (1922–32) * * * have seen wide expansion and a marked increase in the field of industrial hygiene. They have been noteworthy for the large number of scientific investigations undertaken to determine * * * the effects of exposure to specific industrial hazards. Complete reports have been published not only on the effects of such poisons as radio-active paint, methyl bromide, and other refrigerants, and tetraethyl lead, which have become of importance only recently, but our knowledge of well-known health hazards has also been enriched. To mention only a few, benzol, spray painting, and exposure to asbestos dust and to dusts containing free silica, have been thoroughly studied and reported upon.[87]

The question naturally arises as to what types of exposures, possibly resulting in occupational disease, occur in industry and with what frequency.

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[83] Ibid., pp. 581–582.
[84] Ibid., p. 582.
[85] Ibid., p. 594.
[86] U. S. Bureau of Labor Statistics, Occupation Hazards and Diagnostic Signs, Bulletin No. 582, 1933, p. vi.
[87] Ibid., p. v.

* * * Bloomfield, Johnson and Sayers in 1935 surveyed 615 industrial plants in a typical industrial area, involving a total of 28,686 persons. The results of this survey showed that inorganic, nonmetallic dusts accounted for the largest number of exposures, 27.4 percent; carbon monoxide came next with 19.3 percent of the total number of exposure, while lead compounds accounted for 10.2 percent. Exposures to these three substances, therefore, totaled approximately 57 percent. The following table shows the details with reference to these and other types of exposures:

Materials	Number of exposures	Percent of exposures	Materials	Number of exposures	Percent of exposures
Inorganic nonmetallic dusts	7,862	27.4	Carbon monoxide	5,538	19.3
			Lead compounds	2,926	10.2
Emery dust	3,678	12.8	Benzol	1,544	5.4
Quartz dust	2,585	9.0	Turpentine	1,124	3.9
Carborundum dust	793	2.8	Benzine	995	3.5
Other silicates	403	1.4	Methanol	881	3.1
Talc dust	204	7	Aniline compounds	863	3.0
Asbestos dust	199	7	Cyanides	561	2.0
			Ammonia	477	1.7

In connection with this study, the authors were careful to point out that "data on occupational exposures to these materials and conditions must not be interpreted as signifying that workers were being subjected to toxic amounts of hazardous materials, for no quantitative studies of the workroom environment were made. These data merely indicate the potentialities in the plants studied.[88]

The following classification, prepared by Dr. Carroll Daugherty, indicates the scope of occupational groupings in which occupational diseases are a definite hazard.

(1) The dusty trades.
(2) The poisonous trades, other than dusty.
(3) Occupations producing germ diseases.
(4) Occupations producing skin infections.
(5) Occuptations involving extremes in temperature.
(6) Occupations involving work in compressed or rarefied atmospheres.
(7) Improper lighting.
(8) Occupations requiring constant use of certain parts of the body.
(9) Processes requiring artificial humidity.[89]

Each new industry brings its own occupational diseases which may or may not be new forms of poisoning. For example, in the viscose rayon industry, the most common form of poisoning is that from carbon disulphide. While this type of poisoning occurred in connection with some of the early processes of manufacturing rubber products, the extent of the poisoning has gained greatly in the new industry of viscose rayon.[90]

Of especial pertinence is the prevalence of occupational diseases among numerous types of chemical processes. The tendency for metallurgical methods to be replaced by chemical processes (already examined in ch. I), apparently foreshadows an increase in occupational disease. For example, ethylene oxide gas is one of the newer chemical products coming into industrial use. It is an intermediate in the snythesis of other compounds such as methyl, ethyl, and butyl

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[88] C. O. Sappington, Industrial Health, Asset or Liability, Industrial Commentaries, Chicago, 1939, pp. 85–86.
[89] Carroll Daugherty, Labor Problems in American Industry, Houghton Mifflin, Boston, 1933, pp. 126–127.
[90] U. S. Department of Labor, Division of Labor Standards, Occupational Poisoning in the Viscose Rayon Industry, Bulletin No. 34, 1940.

cellosolve, and is used as a fumigant either alone or mixed with carbon dioxide. It has a mild sweetish odor which is not strong enough, however, to give warning of harmful concentrations in the air. Guinea pigs subjected to it suffered successively nasal irritation, eye irritation, bloody discharge from nostrils, unsteadiness on feet and staggering, inability to stand, respiratory disturbances and gasping, and death.[91]

Another example is the revolution in painting, occurring a few years ago upon the introduction of nitrocellulose lacquers in spray-painting (also discussed in ch. I).[92] Such lacquers involve the use of materials which are highly inflammable, unstable, liable to ignite spontaneously, and are conducive to occupational disease.[93]

The probable increasing use of chemical processes in the future by the industrial world presages an increase in the incidence of occupational disease unless stringent protective measures are taken to lessen the impact of these effects of modern technology upon the employed worker.

TECHNOLOGY AND THE OLDER WORKER

It is widely believed that older workers are unable to keep up with the pace of modern technology. But the belief that older workers are less efficient under modern methods of production apparently lacks factual foundation. Productivity of older workers has been found to be higher than the average for all age groups generally in skilled crafts, and frequently in mass-production industries. For example:

> Automobile Facts reports that in the motor industry, where wages are largely on a piece-work basis, and high-speed production is the rule, earnings reach their peak in the group between 50 and 55 years of age. The average annual earnings of that age group in a 1938 period of full production were $1,680. Men over 60 showed average annual earnings of $1,595, which was approximately the figure for those 40 to 45 years of age.
>
> A study made in 1938 by the Industrial Relations Section of the Massachusetts Institute of Technology found in a group of New England plants "no tendency for output and earnings to diminish materially with age except possibly over 60." Thus among a group of cotton textile weavers, age had little effect on earnings between 25 and 55. "They were slightly higher for men aged 45 to 49 and 50 to 54 than for either older or younger workers * * *." Similarly, among cotton spinners, "variations in average earnings by age groups were so small as to be unimportant." [94]
>
> A survey made by the California Department of Industrial Relations in 1930 showed that most employers felt that "age had little relation to efficiency, although some jobs were more appropriate for older men than others." The statement was frequently made by these employers that "workers over 40 or over 50 in good health are as efficient as younger workers." [95]

Laboratory research also shows that productivity does not always decline rapidly after the worker reaches 40.

[91] U. S. Public Health Service, Public Health Reports, vol. 45, Part 2, August 8, 1930, pp. 1832–43. "Acute Response of Guinea Pigs to Vapors of Some New Commercial Organic Compounds," IV, Ethylene Oxide, by C. P. Waite and others.

[92] See pp. 106–107, supra.

[93] "The hydro-carbons and alcohols are diluents and * * * are considered the most harmful of the different constituents of the lacquers. Until a few years ago benzol was the principal diluent, but with an understanding of its extreme toxicity it has largely been replaced by others, the principal one in use now being petroleum naphtha. However, all lacquer vapors are toxic, or at least narcotic, if inhaled in a sufficiently concentrated state for a long enough period of time." (U. S. Bureau of Labor Statistics, Handbook of Labor Statistics, 1936 ed., Bull. No. 616, p. 338.)

[94] Beulah Amidon, Jobs After Forty, Public Affairs Committee, Inc., New York, 1939, p. 19. (This publication was based on materials assembled and prepared by the staff of the U. S. Department of Labor for the Committee on Employment Problems of Older Workers.)

[95] Ibid., p. 18.

Drs. Henderson, Dill, and MacFarland, of the Harvard Fatigue Laboratory, find that the assumption that there is a rapid decline after 40 years of age in the quality and quantity of work is "a social myth which, though in some respects not misleading, is in general grossly inconsistent with the evidence." Summarizing several studies, these scientists state: "First, the rate of decline in the capacities of the industrial worker after 45 years of age has been greatly exaggerated. Secondly, the evidence relative to the changes in abilities of the older worker must be considered in terms of a particular set of circumstances. In some instances, the decline is quite large; in others it is of small magnitude, while there are many conditions of work which indicate that the older man is a distinct asset. Thirdly, the problem is so complicated, with so many ramifications in human physiology and psychology, that at the present time there is little reason for taking the position as a ground for action that in general men over 45 years of age are less effective than others in industrial occupations."[96]

Apparently the driving tempo of modern mass-production fails to lessen the effectiveness of older workers. They also hold their own in trades requiring skilled craftsmanship. For example, a study of productivity of skilled cigar-makers found that the number of cigars per 40-hour week rolled by workers in the 41–50 year-old wage-earner group was 3,090, compared with an average for all age groups of 3,030; 542 of the 1,909 workers included in the sample were in the 41–50 age group.[97]

A study of the efficiency of skilled workers on Works Progress Administration projects[98] found that older workers made an extremely favorable showing both in regard to quality and quantity of work performed. The report observed that—

There was, as a rule, a direct correlation between grades given for quality of work performed and age; the older workers were given the higher grades and the younger workers the lower grades. An exception to this rule was found among the brick and stone masons, where the workers graded as inferior were, as a group, older than those graded as excellent or passable. For all workers combined, however, the average age of workers graded as excellent was 47.5 years, that of workers graded as passable, 44 years, and that of workers graded as inferior, 40.7 years.

There was a direct relationship between the grades given for quantity of work performed and the ages of the workers. The workers who were given inferior grades tended to be the youngest men, those given passable grades, somewhat older, and those given excellent grades, oldest. The average age of all workers graded as excellent was 46.6 years; the average of all those graded as passable was 44.6 years; and the average of all those graded as inferior was 41.6 years.[99]

The percentage of workers performing work of various grades of quality and quantity is shown for each of ten age groups in table 18. This indicates that the strain and hardships of modern industrial life do not affect the performance of older workers to any greater degree than that of younger workers. If there are obstacles to the employment of older workers, their existence appears to be due to factors other than technology.

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[96] Ibid., pp. 19–20.
[97] U. S. Bureau of Labor Statistics, Monthly Labor Review, February 1940, "Individual Productivity Differences," by W. D. Evans.
[98] Works Progress Administration, The Skill of Brick and Stone Masons, Carpenters, and Painters Employed on Works Progress Administration Projects in Seven Cities in January 1937, by W. R. Curtis, W. G. Keim, and Edward Berman, 1937.
[99] Ibid., p. 6.

TABLE 18.—*Percentage of workers in each age group receiving various grades given for quality and quantity of work performed: Brick and stone masons, carpenters, and painters employed on Works Progress Administration projects, January 1937*

7 CITIES

Age class	Total		Excellent		Passable		Inferior	
	Quality	Quantity	Quality	Quantity	Quality	Quantity	Quality	Quantity
24 and under	100.0	100.0	8.3	----------	29.2	58.8	62.5	41.2
25–29	100.0	100.0	18.8	15.6	45.6	53.3	35.6	31.1
30–34	100.0	100.0	27.6	23.5	44.3	50.3	28.1	26.2
35–39	100.0	100.0	29.4	24.4	41.3	47.6	29.3	28.0
40–44	100.0	100.0	41.7	29.8	34.1	48.1	24.2	22.1
45–49	100.0	100.0	42.2	35.0	37.4	47.5	20.4	17.5
50–54	100.0	100.0	41.4	26.0	43.8	55.4	14.8	18.6
55–59	100.0	100.0	50.6	33.6	35.4	52.6	14.0	13.8
60–64	100.0	100.0	51.5	33.3	38.4	53.1	10.1	13.6
65 and over	100.0	100.0	63.9	48.2	22.2	40.7	13.9	11.1
Total	100.0	100.0	38.4	28.3	39.1	50.4	22.5	21.3

Source: Works Progress Administration, The Skill of Brick and Stone Masons, Carpenters, and Painters Employed on Works Progress Administration Projects in Seven Cities in January 1937, by W. R. Curtis, W. G. Keim, and Edward Berman, 1937, p. 60.

CHAPTER III

TECHNOLOGY AND THE COMPENSATORY FORCES

There are certain forces presumably inherent in the present economic order which operate more or less automatically to offset the labor-displacing effects of technology. Principal among these compensatory forces are (1) the reduction of hours (without an accompanying decline in wages), (2) the development of new industries, and (3) the reduction of prices. To ascertain the state of economic balance between the labor-displacing effects of technology and these compensatory forces it is necessary to examine each in some detail. Such is the purpose of this chapter.

THE REDUCTION IN HOURS

Trade-union organizations have continuously urged the adoption of a shorter workweek to offset the labor-saving effected by modern technology.[1] As Dr. Leo Wolman writes:

> The American Federation of Labor, regarding the increased productivity of industry as a cause of the displacement of labor and hence of an increasing rate of unemployment, saw in the reduction of the workweek the most effective means of returning the unemployed to employment. At the same time the view became more generally accepted that the expanding output of "mass-production" industries could be absorbed only by members of a working population who enjoyed more leisure and higher rates of pay.

and further—

> Much of the advocacy of the shorter week is due to the belief that fewer per capita hours cause increased employment.[2]

Hours of work have declined extensively during the last century. In 1851 a union of newspaper compositors in New York City recommended a workweek of six 12-hour days or 72 hours. By 1938 compositors worked 37½ hours a week. Blast furnace employees worked a full-time week of 84 hours as late as 1900; today their hours are down to 40. From 1890 to 1937 the average workweek of factory employees in the United States fell from about 60 to 42 hours, in the building trades from 55 to 39, in steam railroads from 60 to 48, in anthracite and bituminous coal mining from 60 to 35.

This decline in hours has been punctuated by two precipitous dips followed by periods of relative stability. The first abrupt downturn took place during the World War when the average full time workweek fell from 55.1 to 51.0 hours.[3] This was due largely to

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[1] The mere reduction of hours does not necessarily mean an increase in pay rolls. Purchasing power may, however, be increased through the overtime pay which may result from reductions in hours. Also, even though the reduction of hours may mean only a greater spreading of a given pay roll over a larger number of employees, the economy may be stimulated as a result of greater expenditures on necessities at the expense of semiluxuries and savings.

[2] Leo Wolman, "Hours of Work in American Industry," National Bureau of Economic Research Bulletin 71, November 27, 1938, pp. 1, 3, 18.

[3] Ibid., p. 1.

shortages in labor and the resultant competition for workers among industries. The number of hours worked per week then remained relatively stable throughout the twenties.

The second abrupt dip occurred under the National Industrial Recovery Act when the 40-hour week was commonly established by the codes of fair competition, while in certain industries, principally clothing and coal mining, hours were reduced to 35 or 36 per week. For the majority of workers the 40-hour week meant a reduction of 8 to 10 hours a week. For example, in the cotton goods industry only 1.2 percent of the employees were working 40 hours or less in 1929, while 63 percent were working more than 54 hours. The effect of the act was similar in mining where the 9 and 10-hour days were virtually eliminated in 1933. Since April 1, 1934, about 97 percent of the miners have worked a 35-hour week of five 7-hour days.[4] Only in the clothing, printing and publishing, shipbuilding, motor vehicles, and rubber tire industries was there a substantial number of employees who were already on weekly schedules of less than 45 hours by 1933.

In most cases the decreases brought about by the N. I. R. A. have remained in effect due in large part to the increasing organization of labor and the enactment of labor legislation which has been held constitutional by the United States Supreme Court. To determine whether or not any further substantial reduction of hours will occur in the future, there must be evaluation of hours provisions in existent legislation and collective agreements, and of the trend in hours actually worked.

The Fair Labor Standards Act, which became effective October 24, 1938, limited the hours of persons employed in interstate commerce or in the production of goods for interstate commerce (with specified exceptions) to 44 per week during the year beginning October 1938, 42 the second year, and 40 hours thereafter. All time in excess of these hours is considered overtime and must be paid for at one and one-half times the regular rate of pay. The law exempts persons working under collective agreements, certified as bona fide by the National Labor Relations Board, with the provision that such agreements either limit hours to 1,000 in a period of 26 weeks or to not more than 2,000 during any period of 52 consecutive weeks. The law also makes certain exemptions for seasonal industries and specific occupations such as agriculture, merchant marine, and other employments in which working conditions are specially regulated by Federal legislation.

Federal legislation also limits all workers employed in establishments working on Government contracts exceeding $10,000 in value to an 8-hour day and a 40-hour week, and workers employed on projects under the Work Projects Administration and the Tennessee Valley Authority to 8 hours per day, 40 per week, and 140 per month.

A large majority of existing collective agreements between labor and management provide for a 40-hour maximum workweek. With some exceptions the 40-hour week prevails in the iron and steel, stone, rubber, lumber, petroleum, and aluminum industries; in the manufacture of metals, except stoves; in the furniture and upholstery, pulp and paper products, jewelry, pottery, light and power, gas and

[4] Ibid., pp. 9–10.

coke, food products, except flour and cereals, industries; and in the printing trades and certain sections of the building trades. A small number of collective agreements provide for a shorter workweek but the difference between the workweek established and the 40-hour level is relatively small. In coal mining, glass, fur, men's and women's clothing, and newspaper publishing, and in sections of the building, radio, hat, and rubber industries, weekly hours vary between 35 and 37½ per week.

There exist, furthermore, certain industries, small in number however, in which agreements provide for a workweek longer than 40 hours. The 42-hour week is usual in the glass industry and a 44-hour week prevails in some of the building trades agreements. A 48-hour week prevails in collective agreements covering railroad yards, flour and cereal products, the stove industry, retail trade, hotels and restaurants, and a few other industries.[5]

Viewed as a whole, both Federal legislation and existing collective agreements are operating to stabilize the workweek at the 40-hour level. Furthermore, it is not to be expected that labor organizations will press for further hourly reductions as strenuously as they did when hours of work were so onerously long. It is extremely doubtful whether public sympathy could be aroused so readily in favor of reducing the 40-hour week to 30 or 25 hours, as in 1923 when it provoked conferences between President Harding and leaders of the steel industry, leading to the abandonment of the 72-hour workweek.

In regard to the trend of hours worked, the National Industrial Conference Board reports average actual hours per week per wage earner for 25 manufacturing industries from 1920 to 1939.[6] The establishments reporting data in the 25 selected industries cover most of the important branches of industry and include approximately 1,500,000 employees. There are, however, certain defects in the sample: (1) The average hours worked may be affected by the comparatively regular employment afforded by the reporting firms;[7] (2) the sample is heavily weighted by large establishments; (3) it underrepresents industry in the South; and (4) plants working excessively long hours may be expected to understate that fact to any statistical agency, public or private.[8] Because of these limitations the conference Board's data may not always reflect exactly the level of hours at a given time, but the series at least provide a reasonably accurate indication of the long-term trend in hours worked. Average actual hours per week per wage earner from 1920–39 in 20 manufacturing industries are shown in chart XIII and table 19, as reported by the Conference Board.[9]

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[5] International Labour Office, International Labour Review, August 1939, "Hours of Work in the United States," pp. 234–235.

[6] The average actual workweek is generally derived by dividing the total number of hours worked during the week by the total number of wage earners. Variations in the average computed in this way may be caused by short time, by overtime, or by shifts in the workers represented either because different departments are working on different time schedules, or because some workers are working only part of the week, or because they came to or left the plant during the week. In a normal period, actual hours are likely to be shorter than those fixed by collective agreements, regulations, or the nominal schedules of individual plants. In certain circumstances, however, a large amount of overtime may bring actual hours to or even above the nominal figures established in agreements, laws, etc.

[7] See International Labour Office, International Labour Review, August 1939, p. 247.

[8] Leo Wolman, Op. cit., p. 7.

[9] These 20 industries include all of the 25 fields surveyed by the National Industrial Conference Board except 5 divisions of the foundry and machine shop industry. The overall figures of the industry are presented, but the divisions—foundries, machines and machine tools, heavy equipment, hardware and small parts, and other foundry and machine-shop products—were not considered of such importance that one-fifth of all industries included in the survey should be composed of segments of this one field.

Chart XIII

AVERAGE ACTUAL HOURS PER WEEK PER WAGE EARNER

IN SELECTED MANUFACTURING INDUSTRIES

UNITED STATES, 1920-1939

Source: Table 19.

Just as the trend of hours worked tended to become relatively stable during the twenties, following the wartime decline, so also do they appear to be flattening out since the severe depression of 1932–33.

In general, average actual hours remained relatively stable after the 1932–33 decline. In certain industries, such as furniture manufacturing, they turned slightly upward, while in others, such as the boot and shoe industry, they gradually declined. In none of the industries, however, did the post-N. I. R. A. increase take the level

of hours anywhere near the 1929 position. Hours tended to increase slightly up to 1936–37, then turned downward during 1938. From 1938 to 1939 the trend was almost universally upward—only in meat packing did a decline occur. Since the N. I. R. A. decline average hours have paralelled closely their behavior for almost a decade after the World War decline. Although their stability since the N. I. R. A. drop is not so great as during 1920–29, the relatively minor ups and downs appear to offset each other.

If the parallel does prove real, the greater part of a decade will elapse before any further precipitous downswing in hours can be expected. Certainly, the recent upward tendency would indicate that no immediate downturn sufficient to offset the increasing productivity of labor can be expected.

TABLE 19.—*Average actual hours per week per wage-earner in selected manufacturing industries, 1920–39*

Year	Iron and steel	Agricultural implements	Automobile	Foundries and machine shops	Boot and shoe	Leather tanning and finishing	Rubber	Lumber and millwork	Paper and pulp	Paper products
1920 [1]	63.2	48.7	46.1	49.1	44.1	46.2	41.9	48.5	51.3	45.1
1921	54.1	41.3	44.7	42.8	45.7	46.6	43.8	47.7	49.2	40.4
1922 [2]	58.1	48.5	48.2	49.3	46.3	47.7	45.3	49.5	52.7	46.6
1923	57.7	49.5	47.7	49.6	45.6	47.6	44.8	49.5	51.8	47.6
1924	51.3	48.2	45.3	47.5	44.1	46.2	44.1	48.9	49.9	47.5
1925	53.6	49.9	47.3	48.6	45.8	47.5	44.5	49.1	51.3	47.4
1926	54.4	49.6	47.7	49.1	44.6	46.5	45.0	48.0	52.0	47.1
1927	53.1	49.2	46.4	47.9	45.2	45.8	45.4	47.7	51.5	47.4
1928	54.0	49.9	47.7	48.2	44.3	45.2	46.1	47.7	50.9	47.5
1929	54.9	49.6	46.8	49.4	44.2	47.6	44.8	45.4	52.1	49.5
1930	48.9	43.5	39.9	42.8	40.4	44.9	41.4	44.0	49.3	47.4
1931	43.4	35.5	36.9	35.9	44.5	45.2	38.1	40.1	44.1	45.3
1932	27.2	32.9	30.4	30.1	41.1	40.9	33.1	36.4	40.6	41.1
1933	34.0	35.4	36.0	33.1	39.6	41.8	32.7	35.4	41.1	40.5
1934	29.3	38.5	33.5	35.1	37.3	36.6	32.3	35.0	37.5	36.4
1935	34.2	39.7	38.0	37.8	37.1	38.1	33.1	39.3	39.6	38.2
1936	39.8	39.7	42.3	41.4	36.8	39.1	36.6	40.7	42.6	41.0
1937	36.6	40.0	39.6	41.4	38.3	38.2	33.3	40.1	42.1	41.0
1938	27.6	35.1	32.3	34.3	32.8	35.6	30.3	37.8	38.5	38.3
1939	34.6	38.0	34.9	38.6	36.0	38.6	35.5	39.6	40.7	40.0

Year	Printing—newspapers and magazines	Hosiery and knit goods	Cotton goods	Silk goods	Wool goods	Electrical manufacturing	Furniture	Meat packing	Chemicals	Paint and varnish
1920 [1]	44.6	45.1	43.9	41.9	41.9	47.1	46.8	48.5	49.2	49.0
1921	44.4	46.8	42.3	44.9	45.9	43.2	44.4	46.9	50.0	47.3
1922 [2]	44.9	46.8	46.6	45.7	47.6	47.4	48.4	49.2	53.2	49.8
1923	45.0	46.3	47.8	46.5	47.5	47.8	48.2	49.7	53.2	49.8
1924	44.9	43.7	42.7	45.4	43.4	45.6	47.1	49.5	52.2	52.9
1925	45.2	45.1	47.0	46.9	44.1	46.5	47.5	49.6	52.8	52.7
1926	45.3	45.1	46.1	45.2	45.2	46.2	48.0	49.8	50.2	50.8
1927	45.7	47.0	47.2	45.9	45.1	45.1	47.7	50.2	50.0	50.5
1928	45.1	46.8	46.9	47.3	44.4	46.1	46.8	50.6	50.1	50.8
1929	45.7	47.6	48.2	47.8	46.4	47.4	46.9	50.6	50.4	51.8
1930	45.2	43.3	44.6	44.9	41.6	42.8	42.4	50.0	47.5	47.9
1931	43.6	42.2	45.2	44.3	41.8	35.6	39.8	49.0	44.5	44.4
1932	42.1	38.5	42.5	38.9	39.3	29.4	33.6	48.2	40.7	41.4
1933	39.3	39.2	41.8	37.5	39.5	33.2	35.7	44.8	39.1	40.3
1934	36.5	34.6	35.4	31.2	33.0	33.9	34.8	40.9	38.5	38.8
1935	36.2	34.5	36.4	32.1	36.7	36.2	37.8	40.6	39.3	39.9
1936	37.2	35.8	38.4	34.2	36.1	39.2	41.8	41.9	39.9	45.3
1937	37.9	36.6	37.9	35.3	34.7	38.8	40.4	39.8	39.8	41.2
1938	36.6	34.0	35.7	32.3	32.4	33.8	35.3	40.5	37.4	39.0
1939	37.0	36.6	37.9	35.2	35.8	38.2	38.4	40.1	39.3	40.7

[1] Average for last 7 months. [2] Average for last 6 months.

Source: National Industrial Conference Board, Wages, Hours, and Employment in the United States, 1914–36, tables 5–30, pp. 56–159; Conference Board Service Letter, Supplement to June 1938, "Wages, Hours, and Employment in the United States, July 1936–December 1937," tables 4–6, pp. 5–18; Conference Board Economic Record, Mar. 28, 1940, "Wages, Hours, and Employment in the United States, 1934–39," table 4, pp. 120–134.

THE DEVELOPMENT OF NEW INDUSTRIES

THE ECONOMIC IMPORTANCE OF NEW INDUSTRIES

Technology, by bringing forth new industries, causes the economy to expand along three major fronts: (1) Employment opportunities are created for large segments of the working population in the fabrication of the new product; (2) the capital goods industries are stimulated by the placement of orders for needed productive equipment; (3) new industries frequently create activities in the fields of distribution, transportation, service, and maintenance.

Dr. Alvin Hansen of Harvard University well summarized the importance of new industries in his testimony before the Temporary National Economic Committee:

> Thus, throughout the nineteenth century the emergence, development, and growth of giant new industries has played an enormous role, not only in the cycle movement itself, but also in the vigor and intensity of America's booms, and the depth, severity, and length of depression periods. It is my view that the deep and prolonged depression of the nineties relates to the cessation of growth of the railroad industry. There was a temporary lull before the electrical and automobile industries emerged, and similarly in the decade of the thirties, in which we are now living, we are having a similar experience. The great automobile industry has risen to maturity, and no comparable new industry has appeared to fill the gap. It is my growing conviction that the combined effect of the declining population growth, together with the failure of any really important innovations of a magnitude sufficient to absorb large capital outlays, weigh very heavily as an explanation of the failure of the recent recovery to reach full employment.[10]

The importance of new industries is also emphasized by the data in table 20. This shows that 18 new manufacturing industries, which came into existence since 1879, absorbed almost one-seventh of all the labor employed in manufacturing in 1929. The number employed by these industries does not include either those engaged in the production of the necessary capital goods or those required in the fields of distribution, transportation, and service.

It is while new industries are rapidly expanding that they are most effective as stimulants to economic activity. New plants are constructed, new workers are hired, and a new demand is created for materials.

TABLE 20.—*Wage earners in 18 new manufacturing industries since 1879*

Industry:	*Average number of wage earners, 1929*
Electrical machinery, apparatus, and supplies	328, 722
Motor vehicles, not including motorcycles	226, 116
Motor vehicle bodies and parts	221, 332
Rubber tires and inner tubes	83, 263
Manufacture of gasoline [1]	39, 411
Rayon and allied products	39, 106
Manufactured ice	32, 184
Aluminum manufactures	21, 210
Typewriters and parts	16, 945
Refrigerators, mechanical	16, 883

[1] For the reason that gasoline is chiefly used as a source of power in another new invention—the internal combustion motor, around which has been built up one of our greatest industries—the number of employees engaged in the manufacture of gasoline has been estimated for this list.

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[10] Hearings before the Temporary National Economic Committee, Part 9, Savings and Investment, p. 3514.

Industry—Continued.	*Average number of wage earners, 1929*
Cash registers and adding and computing machines	16, 840
Oil. cake and meal. cottonseed	15. 825
Aircraft and parts	14, 710
Phonographs	14, 416
Photographic apparatus and materials	12, 967
Motion picture apparatus except for projection in theaters	10, 784
Asbestos products [2]	8, 092
Fountain pens [3]	4, 508
Total 18 new industries	1, 123, 314
Total, all manufacturing industries	8, 838, 743

[2] Excluding steam packing and pipe and boiler covering.
[3] Estimated.
Source: Machinery, Employment and Purchasing Power, National Industrial Conference Board, Inc., New York, 1935. p. 61.

The importance of a new industry diminishes, however, as it develops sufficient capacity to meet a foreseeable demand, and as the capital goods industries supplying the necessary productive equipment expand to a point where they can meet any expected demand from the new industries. In commenting upon the importance of the growing stage of new industries, Dr. Hansen pointed out:

> In the decade of the twenties the great automobile industry gave a tremendous upward push to our entire economy, running through a vast range of related industries. While this industry still occupies an extremely important place in our economy, there is this highly significant difference, that it is no longer growing and when a revolutionary new industry like the railroad in the last century, or the automobile in our time, after having initiated in its youth a powerful upward surge of plant expansion in all the basic industries which serve its needs, after such an industry reaches maturity and ceases to grow, as all industries finally must, the whole economy must experience a stagnation, unless indeed new developments equally far-reaching take its place.
>
> It is not enough that a mature industry continues its activity at a high level on a horizontal plane; the fact that new railroad mileage continued to be built at a high rate throughout the seventies, eighties, and nineties was not sufficient. It is the cessation of growth which is disastrous, for when they have ceased to grow there is no further need for plant expansion and when giant new industries have spent their force, it may take a long time before something else of equal magnitude emerges.[11]

Certain new industries tend to pass quickly through this vital growing stage, such as those which produce durable goods and are affected by a rapid increase in market saturation. A comparison of specific products in the field of consumers durable goods reveals the effect of market saturation upon sales and upon the change in the stimulus given to the economy by a new industry. Such an analysis has been made by the United States Bureau of Labor Statistics in a report to the Temporary National Economic Committee.[12] Of particular interest here is a comparison of the trend of market saturation to sales in two consumers durable goods—electric refrigerators and vacuum cleaners.

For these products market saturation may be related to wired homes, showing the percentage of the total number of wired homes in the country which possess the commodity under consideration. In 1929 only 9.4 percent of wired homes had electric refrigerators. By 1932 market saturation had risen to 21.6 percent. No decline whatever in the number of electric refrigerators sold occurred in the period 1929–32. As a matter of fact, sales in 1932 were 2.6 percent above sales in 1929. By 1937,

[11] Ibid., pp. 3513–3514.
[12] Temporary National Economic Committee Monograph No. 1, Price Behavior and Business Policy, 1940, Part I, ch. IV, pp. 117–131.

however, 51.7 percent of wired homes had electric refrigerators, and sales in 1937–38 dropped 46.3 percent.

Sales and market saturation in the vacuum cleaner industry are a variation of the same phenomenon. There occurred no marked increase in saturation in vacuum cleaners from 1929 to 1937, the figures being respectively 43.6 and 49.0 percent. But, unlike the electric refrigerator industry which suffered no decrease of sales between 1929 and 1932, the vacuum cleaner industry, with its high saturation in 1929, experienced a 60.1 percent drop in sales. Again in the downswing of 1937, by which time saturation had risen 5.4 points above the 1929 level, vacuum cleaner sales dropped noticeably, falling 24 percent.

In both industries market saturation was at a high level in the "recession" and in both sales dropped abruptly during that downswing. During 1929–32, however, the electric refrigerator industry was characterized by a relatively low degree of saturation and suffered no declines in sales at all, while the vacuum cleaner industry with a high degree of market saturation suffered an extremely severe decline in sales. Thus the growth period of the electric refrigerator industry was less than 10 years, and probably closer to 5, after which time its vitalizing effects on the economy were probably of decreasing importance.

The development of new industries was to a considerable extent responsible for the prosperity of the twenties, which rested, according to Dr. Hansen, upon five factors:

> First, * * * there was residential building, which reached in this decade an all-time high; 8,750,000 urban residential units, not including farm units, were built in this decade. * * *
>
> In the second place there was a high volume of public construction, financed heavily by State and local borrowing. State and local debt increased in this period at the rate of $1,000,000,000 a year. Large capital outlays were made on roads, schools, and other public improvements.
>
> In the third place, there was the outlet for savings in the foreign loans and investments which in part provided foreign countries with a purchasing power to buy from us an excess of exports over imports, amounting to $10,600,000,000 in the decade from 1920 to 1929.
>
> Fourth, there was the growing importance of consumer-installment credit, which financed the purchase of durable consumers' goods and which reached the quite extraordinary level of 11 billion by 1929.
>
> * * * Fifth, there was the prodigious growth of the automobile industry, together with all the related industries which it fostered and sustained * * *.[13]

Along with the automobile industry should be included such new fields as the natural gas industry, the rayon industry, the motion picture industry, and certain segments of the electrical equipment industry. But by far the most important was the automobile industry.

The reduction of automobile prices during the early part of the twenties made it possible for members of the middle-income groups to own automobiles and resulted in a tremendous expansion of economic activity in many major fields. The manufacture of automobiles on a mass-production basis created widespread markets for the iron and steel, gasoline, plate-glass, leather, rubber, lead, copper, aluminum, glycerine, and cotton industries. It also stimulated greatly the machinery industry during the period when new automobile factories were being erected and new technological processes were being constantly introduced. When, however, the automobile industry became equipped with machinery sufficient to produce far more than any rea-

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[13] Hearings before the Temporary National Economic Committee, Part 9, pp. 3512–3513.

sonably expected demand for automobiles, its importance as a market for capital goods began to diminish.

The automobile industry in its rapid development gave direct impetus to other segments of our economy. The construction industry was stimulated as new garages and filling stations were erected. The great expansion in residential construction during the twenties was due in part to the automobile, for it enabled urban workers to commute from their homes in outlying areas. In addition, the automobile industry greatly stimulated the cement and asphalt industries because of the great expansion in road building. Finally, retail and distributing outlets were established to sell automobiles; supplies, equipment and finished cars were transported in increasing amounts; and the servicing and maintenance of automobiles became in itself an industry of considerable size.

Interestingly enough, technology in recent years has tended to reduce the effect of certain of the five bases of prosperity in the twenties mentioned by Dr. Hansen. For example, the expansion of housing during this period rested to no small degree upon the growth of population. Throughout our history the increase in the number of dwellings has maintained a remarkably close relation to the increase of population. From 1916 to 1922, the population of the highly industrialized and urbanized section of the United States (Massachusetts, Connecticut, Rhode Island, New York, New Jersey, Pennsylvania, Ohio, Michigan, and Illinois) increased 10 percent. From 1922 to 1928, there was a further increase of 10 percent in this area, but from 1930 to 1936 the population of this area increased only 3 percent. For the population of the entire country, the percentage increase was 9.1 percent from 1922 to 1928 compared with 4.3 percent from 1930 to 1936. Thus the percentage rate of increase in the urbanized population is less than one-third of that of the twenties, and for the entire country below one-half. To a considerable extent this decline in population can be attributed to a technological development: The contraceptive.

> There is one invention that has an influence on all our businesses. It is not much discussed; rather it is one of those hidden forces, inconspicuous, not imposing, yet having profound influences. Methods of birth control are slowing up the growth of our population. As a market today the population is not expanding as it has done all through American history. In fact in about 25 years it will cease expanding altogether and begin to decline—unless something is done about it.[14]

The export of the techniques of production to nonindustrialized lands has played an important part in reducing the role of foreign trade and the outlet for savings in foreign loans and investments. The United States has sold great quantities of machinery and other capital goods to many nations, including Italy and Japan. Those nations have used that machinery to supply not only their domestic needs but also to manufacture goods in competition with older industrialized countries for the possession of world markets. These

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[14] William F. Ogburn, Machines and Tomorrow's World, Public Affairs Committee, Inc., New York, 1938, p. 9 (pamphlet).

"Thus the influence of contraceptives is, first, to reduce the birth-rate; which, second, lessens the proportion of children in the population; which, third, increases the proportion of old people; which, fourth, leads to a large number of old couples without children, who in former times were an important insurance for elders; and which, fifth, promotes old-age insurance by the State, a derivative effect not readily foreseen." ("The Influence of Inventions on American Social Institutions in the Future," by William F. Ogburn, The American Journal of Sociology, November 1937, p. 369.)

newly industrialized nations have acquired more and more machinery and related capital goods, either by importing them or constructing them with techniques already imported, and in recent years have been exporting capital goods to other nations not highly industrialized at the present time.[15]

With technological developments affecting both population—and indirectly construction—and foreign trade, and with the automobile industry beyond its growth period, it appears that the five stimuli to prosperity in the twenties, discussed by Dr. Hansen, must be regarded as an aggregate stimulus peculiar to that decade.

LIMITATIONS OF THE NEW INDUSTRY STIMULUS

The possibilities of economic expansion by the development of new industries are limited because (1) the substitution of new products for old may, through lower unit labor requirements, decrease net employment, (2) new technological developments may lessen the requirements and outlays for new capital goods, and (3) present income distribution limits the market for new products. New industries can offset the effects of labor-saving technology only if these three limitations are overcome.

The Principle of Substitution.

The mere development of a new product, or perhaps a new industry, does not necessarily result in a net gain in employment and purchasing power equivalent to the consumption of the new product. The new good may be merely a substitute for an older commodity. The extent to which a new, but substitute product, will bring about a net gain in employment is determined not only by the increase in its consumption over the old product, but also by the ratio of its unit labor requirements to those of the older commodity. While more units of the new product may be sold than of the old, this gain might be offset by lower unit labor requirements in the production of the new commodity. For example, if the annual consumption of the new product amounted to 1,000,000 units compared with one-half a million of the old, this gain would be offset if the unit labor requirements of the new product were 50 or more percent lower than those of the old.

The widespread occurrence of substitution has already been discussed in the section on types of labor-saving techniques.[16] The examples of recent replacements cited there should leave no doubt that the trend in the development of new products is toward the creation of those which involve lower unit labor requirements than the items they replace. Present tendencies indicate that an increasing proportion of new commodities will be produced by chemical or electrical processes. If these new commodities are substitutes, they will have to be consumed on an extremely wide scale to offset the

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[15] See John M. Blair, Seeds of Destruction, Covici-Friede, New York, 1938, ch. 13, "Total Exports and Machinery Exports."

To cite one example, processes for direct rolling of nonferrous metals are among the most recently developed techniques of production. Shortly prior to 1937 "a 20-inch mill for direct rolling of brass and copper was shipped from this country to Japan. It has a capacity of 1 ton in 4 minutes." (See National Resources Committee, Technological Trends and National Policy, 1938, "Metallurgy," by C. C. Furnas, p. 356.)

[16] See pp. 106–110, supra.

almost laborless character of such processes and thus to prevent a net decline in employment.

Many writers minimize the possible destructive effects of new industries. Perhaps an insight into this tendency may be gained by an examination of a recent work by Carl Snyder, Capitalism the Creator, wherein he has a chapter entitled "The Unlimited Potentials of Tectonics" in which he cites several examples of the ways new industries become established or may yet develop without harming the commodities they are replacing. He has nothing but scorn for the idea "that new industries are coming in to ruin old industries and create unemployment."[17]

One of Dr. Snyder's examples follows:

> Another wonderful rejuvenation of an industry: In the last 10 years of stagnation we have been hearing much about the difficulties of the coal industry, and dismal prophecies as to its future. That its growth has ceased. And now come new methods of mining and cleaning the coal so that where adequate capital can be employed, there will be cheaper and more efficient methods. This is only the beginning. The rest is a vista of a dumfounding revolution: That coal may in large part be no longer used for fuel! At least save where it is exceptionally advantageous, and perhaps then principally in the form of coke or briquets. Its all important value will be the vast variety of chemicals which will come from coal tar. Already a perfect troop of new medicines, new dyes, and new plastics, and a wide variety of other products. So that the prediction has already been made that with this astounding advance of industrial chemistry, a day is near when coal will be too valuable to burn as of yore.[18]

It is evident, as previously pointed out in this report,[19] that coal is feeling the inroads of competing fuels and that these fuels require considerably less labor per unit of heat than coal. But Dr. Snyder apparently believes that the market created by the demand of the chemical industry for coal tars will fully offset the losses suffered by coal to competing fuels. It is extremely unlikely, however, that the employment created by the demand for coal tars will offset the labor displaced by the substitution of new fuels because a tremendous amount of coal-tar products can be produced from a relatively small amount of coal.[20]

It must be remembered also that the coal-tar industry has been in existence for many years, that its products are today widely used in

[17] Carl Snyder, Capitalism the Creator, Macmillan, New York, 1940, p. 395.
[18] Ibid., p. 398.
[19] See pp. 99–106, supra.
[20] The relative unimportance of industrial chemicals as a market for coal is to be seen in that the coal used in the manufacture of the byproducts in 1937 amounted to 69,573,000 tons, or 14.5 percent, of the Nation's entire coal production of 479,400,000 tons. Of this byproduct use, coke and manufactured gas were by far the largest components. Byproduct coke ovens yield several commodities during the coking or distillation of coal. The value of the principal products as derived in 1937 was as follows:

	Value of byproducts per 1 ton of coke
Gas	$1.48
Coke	4.42
Tar	.59
Benzol	.41
Ammonia	.33
Others	.25

(United Mine Workers of America, Engineering Department Monograph No. 3, Manufactured Gas Versus Natural Gas, by Walter N. Polakov, 1940.)

Of these possible components, coke is used principally for metallurgical purposes, leaving but a very small proportion for industrial chemicals, which, together with tar, benzol, and ammonia, as possible sources of industrial chemicals, constitute a very small segment of the byproduct use of coal and an insignificant proportion of the total coal production.

industry, but that nonetheless unemployment in the coal industries has grown apace until today it is a social problem of the first magnitude. Another illustration cited by Dr. Snyder:

> In the same way cotton may in the near future be no longer used as cotton, save under special conditions, and in the higher grades. Already experiments are well advanced toward the planting and cultivating and harvesting of cotton just as if it were wheat, sowing the plants closely together so as to conserve the moisture and save the cost of cultivation; then to harvest with a mowing machine, or perhaps with a harvester-combine. Then to put the entire plant with the cotton bolls into the digester, and rapidly transform it into high grade cellulose. Estimated to be a cheaper product, of a higher quality, than that being made from any other kind of pulp. Possibly a new future and a new hope for the dying agriculture of the Southern States.[21]

The possible development of this process of transforming cotton into high-grade cellulose and then into textiles raises the question of the fate of those thousands of workers now engaged in processes which would be entirely eliminated under this new method.

Or again:

> There is an exhibit of a new glass thread almost as strong as steel and flexible, impervious to water, and *mirabile dictu*, it is now being woven into glass cloth for a wide variety of uses. Glass dresses have been made for years. They may soon drive out silk and rayon as these have driven out cotton.[22]

The substitution by rayon textiles has been a mixed blessing with many textile workers displaced in the process. If the production of glass fabrics involves lower labor requirements than silk and rayon, their replacement by glass may well have adverse effects upon the economy. On the other hand, the substitution of glass fabrics for silk and rayon may increase the consumption of textiles to such an extent that the total amount of labor involved in producing textiles will be augmented. Perhaps the development of the glass fabrics industry will require large amounts of capital goods and so stimulate the economy as a whole. It may happen that glass fabrics will sell at a lower price and release a larger part of the consumer's dollar for the purchase of other products. But these are merely favorable possibilities; they are by no means certainties.

These uncertainties emphasize the necessity of evaluating the possible good and bad effects of each technological innovation which may be substituted for an existent product.

An evaluation of the great industry-creating technological innovations of the 1920's, presented before the Temporary National Economic Committee by Dr. Isador Lubin, is of particular interest here because it stresses the importance of substitution.

> Take automoble and truck transportation. There is no doubt that automobile and truck transportation displaced a large number of people who were engaged in activities which had to do with horse transportation, but, offsetting that, you had road-building and petroleum refining and steel and rubber and textiles and glass and real estate, and a thousand and one other activities that would not have been possible without the automobile. So there again you had a net increase in the number of people who were employed.
>
> The gross increase in employment in these new activities was, of course, offset by the displaced employment in vehicle industries and stables and raising mules and horses and water transportation and horse trading, but, by and large, we will admit that the net has been a gain to the country as a whole in the total number of jobs.
>
> Again, there are movies. Employment was created in book-writing and in making film and in the production of movies and distribution of movies, and that

[21] Carl Snyder, op. cit., pp. 398–399.
[22] Ibid., p. 399.

net was greater than the number displaced among vaudeville artists and musicians.

Rayon is another case in point. Through improved quality and through lower prices, there was a large increase in employment which was offset in part by losses in the silk industry and in other natural fibers like wool and cotton.

Electric power again created employment through endless possibilities for cheaper light and cheaper power. On the other hand, it created unemployment in coal and gas and oil, but again I believe there was a net increase for the country as a whole.[23]

When it is realized that even these tremendous new industries have had certain negative effects, it becomes apparent that the probable overall results of less pretentious innovations must be analyzed carefully lest they bring losses instead of gains to the economy.

Capital-Saving Characteristics of Modern Technology.

The assumption that a new industry in developing expands employment and increases purchasing power because it creates a large demand for capital goods is not always warranted, since there are two closely related characteristics of modern technology which operate to reduce greatly the extent of this demand. The so-called capital-saving innovations will be considered first.

Certain types of equipment have been developed, particularly in recent years, which achieve substantial increases in production with a relatively small amount of capital outlay and a comparatively small expenditure of labor. For example, the production of industrial instruments involves little labor; yet, as previously noted,[24] they have proved most effective in increasing output. The development of controlling devices which safeguard machinery against breakdowns and excessive wear has lessened greatly the continual demand for capital goods caused by rapid obsolescence. Industrial instruments not only reduce the volume of replacement orders in the capital goods industries but they also make possible careful analyses of existing industrial equipment to determine whether it is being used to its fullest capacity. In many cases greater productivity is then secured merely by operating existent equipment at a higher tempo.

The use of new alloys for metal tools and parts is another method of enlarging production which exerts only a small demand on capital goods.

A particularly significant development under way is the growing use of new material for cutting tools, first in the form of tungsten carbide, introduced in this country in 1928, and now tending to be replaced by a mixture of tungsten and tantalum carbides. The use of this material results in a tool of greater hardness, able to withstand the wear of high-speed machine cutting, with a great resistance to high temperatures. Introduction of these carboloy tools has brought about increased speed of operation, increased feed, and longer life between sharpenings. * * *

Thus, on a brass-plug job, the number of pieces that can be finished between sharpening was increased, through the substitution of carboloy tools, from 200 to 15,000. * * * In work on phenol resins, * * * a 10-inch saw fitted with 14 carboloy teeth cuts approximately 10,000 feet of material without refitting, and its introduction permitted a daily volume of cutting larger than the monthly volume attained by former methods.[25]

In view of the above, if a new industry were to require a saw in its production processes it could be expected to use, if possible, one with carboloy teeth, and thus there would be exerted a much smaller demand for capital goods.

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[23] Hearings before the Temporary National Economic Committee, Part 30, pp. 17247–48.

[24] See pp. 137–138, supra.

[25] Works Progress Administration, National Research Project, The Effects of Technological Developments Upon Capital Formation, 1939, p. 9.

Many new chemical processes are put into operation with extremely small capital expenditures. In the beet-sugar industry the mere improvement of chemical processes has contributed to increased productivity, raised the proportion of the sugar extracted from the beets, and increased the capacity of the plants.[26] Chemical processes are among the most important capital-saving techniques.

To cite another example:

> Even in the telephone industry, which has always been regarded as the classic example of an industry subject to diminishing returns where fixed capital requirements grew faster than increases in the number of telephones installed, recent and current technical changes such as the introduction of carrier current systems of the coaxial cable are increasing the capacity of the telephone plant with less than a proportional increase in fixed capital investment.[27]

The great adaptability of numerous existent techniques is similar to capital-saving innovations in the effect upon employment in the capital goods industries. Numerous techniques can readily be changed, after turning out one type of good, to produce a comparatively unrelated and often dissimilar product. This obviates the necessity of acquiring new equipment. If a considerable proportion of our potential new products could be produced in large quantities merely by slightly readjusting or rearranging existing techniques, the demand for capital goods—and the labor involved in their production—would be materially lessened.

This adaptability has recently been impressively demonstrated by the fulfillment of requirements for the national defense program. Certain techniques are so adaptable that with practically no capital outlay they have easily been shifted from the production of peacetime goods to the manufacture of unrelated wartime products.

Three examples of the great adaptability of general-purpose techniques deserve special attention. (1) Without any change whatever in the process, welding has been applied to the large-scale manufacture of airplane bombs formerly produced from forgings. Gun carriages are now made by means of structural welding in place of the former method which involved forging, casting, and riveting. (2) The punch press has been easily adapted to the manufacture of clips for rifle bullets and of all types of standard quartermaster hardware—belt eyelets, etc. Draw presses, originally designed to produce acetylene gas bottles or large milk cans, are now turning out cartridge cases in great numbers. (3) The automatic screw machine is capable of making practically any small metal part in enormous quantities. Its value to national defense is chiefly in the production of fuses, boosters and primers of ammunition. As in the case of the press and of welding, the screw machine was adapted to this new use with practically no capital outlays.

Through the use of these and other techniques, certain types of plants equipped chiefly with general-purpose machinery have been able to shift with little added expense to the production of wartime goods. Farm implement manufacturers readily adapted their processes to the production of small gun carriages, transmissions for tanks, and machine-gun tripods. Equipment for the production of printing presses was found readily adaptable to the manufacture of gun carriages, gun tools, and recoil mechanisms. Makers of heavy Diesel engines went readily into the production of cannon and mount-

[26] Ibid., p. 10.
[27] Hearings before the Temporary National Economic Committee, Part 30, exhibit 2438.

ings for cannon, while crane and shovel firms shifted to the manufacture of gun carriages and railway mounts. Similarly, locomotive producers found that with little added expense they could turn out gun carriages, and the transmission, driving, and track mechanisms of tanks. Manufacturers of heavy electrical equipment shifted to the production of such diversified goods as turbines, drive shafts for destroyers, cannon, and gun carriages.

Manufacturers of cash registers and adding machines changed to the production of bomb fuzes. Factories formerly producing ladies' underwear shifted to mosquito netting for troops in the field. Makers of vacuum cleaners transformed their processes to the mass-production of gas masks. Among the more unusual adaptations was the change by manufacturers of church pipe organs to the production of wooden framework for army saddles. Likewise, firms which had been making lathes to turn out wooden ducks for shooting galleries went readily into the production of lathes for army shoes.

These examples illustrate an adaptability which is by no means confined to shifting to the production of wartime goods. New products do not necessarily require new types of capital goods if they can be produced with the highly adaptable general-purpose techniques now installed and in operation.

It is evident that (1) new industries can develop and greatly increase their production by using capital-saving innovations and (2) the production of new and different products can often be effected merely by minor changes in existing techniques. Therefore, the emergence of new industries does not necessarily create a great demand for capital goods with a resultant expansion of activity throughout the entire economic system.

The Pattern of Present Income Distribution.

The existing pattern of income distribution is a third limitation upon the stimulating effect of new industries. Because over two-thirds of the Nation's families and individuals are in the lower-income groups, the market for new products is automatically limited. Table 21 shows the percentage of families and single individuals receiving incomes of various levels during 1935–36.

About one-third (31.64 percent) of the total number of families and single individuals received incomes of less than $750, nearly one-half (46.54 percent) less than $1,000, and over two-thirds (68.68 percent) less than $1,500. At the other end of the income scale, about 2 percent had incomes of $5,000 and over, and less than 1 percent, incomes of $10,000 and over.

TABLE 21.—*Distribution of families and single individuals, by income level, 1935–36*

Income level	Families and single individuals		
	Number	Percent at each level	Cumulative percent
Under $250	2, 123, 534	5. 38	5. 38
$250 to $500	4, 587, 377	11. 63	17. 01
$500 to $750	5, 771, 960	14. 63	31. 64
$750 to $1,000	5, 876, 078	14. 90	46. 54
$1,000 to $1,250	4, 990, 995	12. 65	59. 19
$1,250 to $1,500	3, 743, 428	9. 49	68. 68
$1,500 to $1,750	2, 889, 904	7. 32	76. 00

TABLE 21.—*Distribution of families and single individuals, by income level, 1935–36*—Continued

Income level	Families and single individuals		
	Number	Percent at each level	Cumulative percent
$1,750 to $2,000	2,296,022	5.82	81.82
$2,000 to $2,250	1,704,535	4.32	86.14
$2,250 to $2,500	1,254,076	3.18	89.32
$2,500 to $3,000	1,475,474	3.74	93.06
$3,000 to $3,500	851,919	2.16	95.22
$3,500 to $4,000	502,159	1.27	96.49
$4,000 to $4,500	286,053	.72	97.21
$4,500 to $5,000	178,138	.45	97.66
$5,000 to $7,500	380,266	.96	98.62
$7,500 to $10,000	215,642	.55	99.17
$10,000 to $15,000	152,682	.39	99.56
$15,000 to $20,000	67,923	.17	99.73
$20,000 to $25,000	39,825	.10	99.83
$25,000 to $30,000	25,583	.06	99.89
$30,000 to $40,000	17,959	.05	99.94
$40,000 to $50,000	8,340	.02	99.96
$50,000 to $100,000	13,041	.03	99.99
$100,000 to $250,000	4,144	.01	100.00
$250,000 to $500,000	916	(1)	
$500,000 to $1,000,000	240	(1)	
$1,000,000 and over	87	(1)	
All levels	39,458,300	100.00	

1 Less than 0.005 percent.

Source: National Resources Committee, Consumer Incomes in the United States, Their Distribution in 1935–36, 1938, table 2, p. 6.

The overwhelming number of persons included in the lower-income groups indicates that a mass market for any new product must be created principally among them. But the development of such a mass market depends upon making it possible for the poorer families to purchase more than the primary necessities of life. The proportion of income a family may spend for new products, which are not substitutes for existent items of food, clothing, shelter, and personal care, can be measured only in terms of what remains after these necessities are purchased, since members of the lower-income groups cannot be expected to decrease materially their already meager expenditures on essentials. Thus, the potential market for new commodities, outside the field of primary necessities, should be measured in terms of the consuming units' income residual (income remaining after expenditures for food, clothing, shelter, and personal care). The Bureau of Labor Statistics has computed this income residual and has represented it as a percentage of total income for nonrelief families in cities of varying size throughout the United States.[28] The percentage of income residual to total income by various income groups is shown in table 22 taken from the above-cited report. The income residual of the members of lower-income groups is extremely limited. Over two-thirds of all consuming units receive less than $1,500 annually and their income residual generally amounts to less than 20 percent of their total income. In many cases, families in the lowest income brackets (under $750) actually spend more than their total incomes (a practice made possible in the case of nonrelief families by the use of credit or past savings).

[28] Temporary National Economic Committee Monograph No. 1, Price Behavior and Business Policy, pp. 130–133.

TABLE 22.—*Income residual after primary expenditures*[1] *by income groups, 1935–36*

NON-RELIEF WHITE FAMILIES, INCLUDING HUSBAND AND WIFE, BOTH NATIVE BORN[2]

Family income class	New England				East Central				West Central		Southeast		Rocky Mountain		Pacific Northwest	
	Metropolis	Large cities	Middle sized cities	Small cities	Metropolis	Large cities	Middle sized cities	Small cities	Large cities	Middle sized cities	Large cities	Middle sized cities	Large cities	Middle sized cities	Large cities	Middle sized cities
$250 and under $500	....	....	−69	−28	....	....	−28	−23	....	−32	....	−15	....	−39	....	−20
$500 and under $750	−43	−5	−6	−11	−16	1	−2	3	(3)	2	8	5	−4	−6	−2	3
$750 and under $1,000	−8	9	6	10	2	10	9	14	12	12	9	16	12	5	11	20
$1,000 and under $1,250	7	13	13	14	10	16	16	16	14	19	15	18	19	15	21	21
$1,250 and under $1,500	10	17	16	22	15	21	20	25	19	22	21	21	23	19	24	28
$1,500 and under $1,750	15	19	21	20	19	25	25	26	23	27	23	22	25	28	30	29
$1,750 and under $2,000	17	24	22	27	23	28	29	30	26	30	24	26	28	24	31	30
$2,000 and under $2,250	18	23	29	29	26	30	31	30	30	34	29	28	29	32	33	32
$2,250 and under $2,500	22	29	29	30	25	32	35	34	34	36	30	33	34	33	35	36
$2,500 and under $3,000	24	30	34	33	29	37	37	37	35	37	33	32	36	31	35	39
$3,000 and under $3,500	26	31	33	41	35	37	39	49	36	41	35	38	37	37	41	39
$3,500 and under $4,000	29	40	42	....	35	42	43	....	41	47	36	41	40	41	43	42
$4,000 and under $5,000	28	38	46	....	38	44	46	....	42	46	41	42	43	42	46	49
$5,000 and under $7,500	32	42	45	....	45	45	57	....	43	58	45	52	46	57	51	51
$7,500 and under $10,000	36	46	....	....	46	52	....	....	55	....	59	....	53	....	61	....
$10,000 and over	51	....	....	....	61	68	....	....	....	....	....	....	....	....	....	....

[1] Figures show percent of income remaining after expenditures for food, home maintenance, clothing, and personal care are made.
[2] Family types covered are as follows:
Family type:
I. 2 persons. Husband and wife only.
II. 3 persons. Husband, wife, 1 child under 16, and no others.
III. 4 persons. Husband, wife, 2 children under 16, and no others.
IV. 3 or 4 persons. Husband, wife, 1 person 16 or over, and 1 or no other person regardless of age.
V. 5 or 6 persons. Husband, wife, 1 child under 16, 1 person 16 or over, and 1 or 2 other persons regardless of age.
VI. 5 or 6 persons. Husband, wife, 3 or 4 children under 16, and no others.
VII. 7 or 8 persons. Husband, wife, 1 child under 16, 4 or 5 other persons regardless of age.
Family Types VI and VII appear in East Central Region only.
[3] Less than one percent.

Source: Temporary National Economic Committee Monograph No. 1, Price Behavior and Business Policy, 1940, p. 265.

If a family receiving $1,500 a year has an income residual of only 20 percent, or $300, this constitutes its buying power for products other than absolute necessities. A new product, which is a non-necessity, must compete for a share of this $300 with items of transportation, personal care, medical care, recreation, tobacco, drugs and cosmetics, and taxes. If the new product competes with an old product within any of these fields, the substitution involved may well reduce sharply the stimulus of the new industry.

The Bureau of Labor Statistics examined the market for certain household equipment in relation to the size of the income residual and concluded that, due to the smallness of the income residual among the lower-income groups:

> The opportunities of purchasing such products as refrigerators, vacuum cleaners, or washing-machines are correspondingly limited.
>
> This does not mean that the lower income groups must be dropped from consideration as a potential market for these goods. * * * Obviously, if these markets are to be tapped, prices must be low and payments must be extended over substantial periods of time.[29]

The smallness of the income residual among the lower-income groups will not necessarily prevent the development of any new industry. But since the bulk of the Nation's purchasing is done by the lower-income groups, any new consumers' good which is not a substitute for an existent necessity, must compete with many other products for a share of the lower-income groups' purchasing power available for the acquisition of non-necessities, purchasing power, which, per family, is extremely limited by virtue of the present pattern of income distribution.

PROSPECTIVE NEW INDUSTRIES

It is impossible to determine precisely what new industries will develop in the future to stimulate materially the rate of economic activity. As Dr. Alvin Hansen has said.

> Certainly no one can say at this moment what great new developments the future may hold in store, but I should like to call attention to what seems to me to be a fact, namely, that economic progress, even in the nineteenth century, came by spurts and not at a uniform rate. Such notable students of economic development as Spiethoff, Wicksell, Cassel, Schumpeter, and Robertson stress the discontinuity, the jerkiness and lumpiness of economic progress.
>
> The history of the last 200 years affords no basis for the assumption that the rise of new industries proceeds at a steady pace.[30]

Between 1900 and 1933, 32 inventions or improved processes of primary importance were developed according to Lewis Mumford's list of important inventions, based largely upon the compilations of Darmstaedter and Feldhaus.[31] These developments have been occurring at a diminishing rate in recent years. From 1900–13, 28 of the 32 developments took place, but from 1920–33 only four occurred. It seems that as our body of technical knowledge increases, the rate of new industry development declines. It is indeed possible

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[29] Ibid., p. 131.

[30] Hearings before the Temporary National Economic Committee, Part 9, Savings and Investment, p. 3514.

[31] Lewis Mumford, Technics and Civilization, Harcourt, Brace & Co., New York, 1934, pp 437–446.

that the rapid pace of new industry development which has been a feature of the past may not characterize the future.

General Fields of Inquiry.

Certain fields give some promise of future developments. Watson Davis, Director of Science Service, has listed eight such fields, selected with the cooperation of a number of representative scientists and engineers throughout the country.

According to Dr. Watson, "These fields are photosynthesis, atomic power, long-range weather forecasting, synthetic materials, chemical cures of disease, genetics, human relations, and mobilization of scientific knowledge." [32] This section very briefly analyzes these fields as to their present state of scientific development and their possibilities of developing into important employment-creating industries.

1. *Photosynthesis.*—Green plants convert solar energy into useful materials for mankind by photosynthesis, but the manner in which the plant accomplishes this still remains unknown. "According to Dr. O. L. Inman, Director of the Kettering Foundation for the Study of Chlorophyl and Photosynthesis at Antioch College, the best estimates are that the energy reaching the earth from solar radiation each year is equivalent to that received from burning 400 septillion tons of anthracite coal." [33] If only a minute fraction of this enormous amount of energy were directly convertible, any potential problem of adequate power in the future would be completely solved.

If chemical techniques are developed to accomplish photosynthesis artificially, coal, fuel oil, and natural gas would be eliminated as sources of power, but society would gain a much cheaper and more adequate source of energy. Similarly, this development would undoubtedly revolutionize agriculture.

The attainment of controlled photosynthesis, however, appears to be so far distant that it should not be relied upon as a prospective employment-creating industry.

2. *Atomic power.*—This possible development has already been briefly discussed in the section on power and energy development.[34] There are vast untapped stores of energy within the atom which, if released, would furnish almost unlimited amounts of power. The active component of uranium has been separated and its atoms split with the release of an enormous amount of energy. But atom smashing apparatus can only be used at present in the laboratory. As in the case of photosynthesis, its attainment, unlikely in the near future, would probably displace a vast amount of labor, and this displacement would have to be offset by an enormous expansion in industrial activity if no net decline in employment were to occur.

3. *Long-range weather forecasting.*—

If it were possible to know what the weather was to be next year or several years from now, whether the growing season in various regions was to be satisfactory or unsatisfactory, whether the winter was to be abnormally cold, whether there was to be too little or too much rain, the savings to agriculture, industry, and the Nation would be very large.[35]

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[32] Hearings before the Temporary National Economic Committee, Part 30, p. 16274. The following description of the present state of scientific development in all of these fields is adapted from the material presented by Dr. Davis to the Temporary National Economic Committee.

[33] Ibid., p. 16275.

[34] See pp. 105–106, supra.

[35] Ibid., p. 16283.

Long-range forecasts for the United States are considered probable in the future by Dr. Charles F. Brooks, director of the Blue Hill Meteorological Observatory of Harvard University, but there are many research problems to be solved before they become practicable.

Even if long-range weather forecasting were possible in the near future, it would create only very limited employment opportunities. Its value to society would undoubtedly be considerable, but its possibilities of being a major stimulant to economic activity are extremely remote.

4. *Synthetic materials.*—Synthetic materials have already been discussed.[36] Many synthetic materials are already in use: Drugs, dyes, and chemicals from coal tar; a multiplicity of plastics or synthetic resins; alloys of iron and other materials; rayon; etc. In the last few years chemistry has brought forth several new textiles: Nylon, a silk-like synthetic fiber made basically from coal, air, and water; vinyon, another synthetic fiber; synthetic wool, made from casein or other protëin; and glass fibers. Clay has been transformed into synthetic mica which makes the Nation potentially independent of foreign supplies. Substitute materials, though bringing enormous benefits to society, often result in a reduction of employment where, as is often the case, less labor is required in their production than in the commodities which they replace and output is not sufficiently increased to compensate for the attendant decline in unit labor requirements.

5. *Chemical cures for disease.*—Remarkable success in the use of sulfanilamide and its related chemical compounds in treating a variety of diseases focuses attention upon the possibility of new chemical cures for disease in the future. It is unlikely, however, that either the discovery or production of new chemical cures would create many employment opportunities since chemical processes require only a relatively small amount of labor. But the further use of chemical cures may counteract somewhat the present decline in population growth by lengthening the span of life and permitting individuals to engage in active work during a longer period of their life. As a source of new employment, however, the production of chemical cures for disease must be considered unimportant.

6. *Genetics.*—Since the turn of the century considerable advances have been made in scientific breeding of both plants and animals. Superior grains, fruits, and vegetables, and superior animals from the standpoint of meat and wool production, are indications of the economic possibilities of applied genetics. The economic value of cross-bred seeds which give increased yields because of hybrid vigor and of rust-proof and disease-proof crops is evident. Important raw materials, such as cellulose from cotton, paper pulp, and cornstalk waste, as well as plants for food, are all controllable by genetics methods.

Genetics is another field in which further developments may be of great value to society but scarcely promises the emergence of a vast new industry. As E. D. Merrill, administrator of the botanical collections of Harvard University, says:

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[36] See pp. 106–110, supra.

It is very difficult for one to indicate the tangibles in genetics in reference to plants and plant breeding. I personally doubt if any new major industries can be developed on the basis of research in this field. * * * New significant social developments could hardly be expected, but the increased utilization of knowledge in industry would have a very favorable reflex action on our whole social set-up.[37]

7. *Human relations.*—As Dr. Davis stated:

Human relations in the factory, in the community, and in the home might not seem to be at first consideration a problem for research and technology. As a matter of fact, it seems probable that the methods of scientific research applied to this great problem in which the reagents are human beings will be capable of producing useful and fruitful results with as much assurance as they do in less animate fields. * * * Man, as an individual and in the group, is the subject of investigation by psychologists, psychiatrists, teachers, administrators, and others who deal with various human problems. It would seem logical that some of the findings in these fields might be applied profitably to the difficult relations in the fields of business, politics, and international affairs.[38]

This field, however, is still in its infancy. Its principal economic value in the near future will probably be the devising of new personnel procedures. It will thus provide employment for a very small number of highly trained specialists but its importance as an expansionist force in the economy will be negligible.

8. *Mobilization of scientific knowledge.*—In the word of Dr. Davis:

With the accelerating pace of scientific research, invention, and development, the distribution, interpretation, and utilization of the knowledge already obtained becomes an increasingly important problem. * * * The great failure to our organization of our written knowledge lies in the inability of anyone to put his finger upon all the literature on a given subject with relative completeness and at a reasonable cost. Our organized knowledge, as contained in the printed literature, is extraordinarily poorly indexed from the standpoint of its efficient utilization.

In a few fields, such as chemistry, there are abstract journals which do an invaluable job. But in many fields bibliographic resources are quite inadequate, resulting in investigators not being able to discover what researches have been made in a particular line of inquiry in the past. New mechanisms recently developed, or in the process of development, which may be called new tools for intelligence are likely to prove useful in this needed mobilization of knowledge.[39]

Of these mechanisms, the card index and microfilm are of primary importance. The latter can produce at low cost single-copy editions of anything a camera can see.

The indirect benefits to society of marshaling available scientific knowledge would undoubtedly be immeasurable, but the employment opportunities directly created thereby would scarcely exceed several thousand.

Further developments in these eight fruitful fields, selected by Watson Davis and participating scientists and engineers, would undoubtedly greatly benefit mankind, yet it is unlikely that a great employment-creating industry will emerge from any one of them in the near future. In the first place, several of the eight, such as photosynthesis, appear to be far distant in regard to practical usefulness. Others, such as synthetic materials, would result in the replacement of an existent product by a new material; since in all probability the new material would be produced with lower unit labor requirements than the old, its introduction would stimulate economic activity only if there resulted an offsetting expansion in production.

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[37] Hearings before the Temporary National Economic Committee, Part 30, p. 16288.
[38] Ibid., p. 16289.
[39] Ibid., p. 16290.

A third group, such as the mobilization of scientific knowledge, would serve a very useful purpose, which, however, can be realized with an extremely small increase in employment.

For example, it is difficult to see in these fields the promise of a new industry comparable in its effect upon the economic system with the railroad industry in the last century or the automobile industry in the 1920's.

Specific new industries.

Several new industries have each been described at one time or another as "the coming new industry," but their effect upon economic activity is still problematic. These industries are prefabricated housing, air-conditioning, television, and Diesel engines, each of which will be briefly examined with reference to its possibilities of developing into a great new industry.

1. *Prefabricated housing.*—Though a number of the parts used in building a house are already prefabricated on a mass-production basis—for example, doors and windows (where stock sizes are used and glazing is allowed off the job), furnaces, lighting fixtures, etc.—repeated attempts have been made to put entirely prefabricated houses on the market in order to reduce field assemblage to a minimum.[40] Sears, Roebuck & Co. have tried to popularize pre-cut houses, all lumber and parts to be fitted on site. Although they sold a large number of houses, little saving resulted from this method. Similarly, steel companies turned to the prefabricated field during the depression but were unsuccessful in reducing the cost of houses much below those built by ordinary site assemblage.[41]

About 50 efforts have been made to produce prefabricated houses, but none apparently has been successful in achieving marked reductions in cost. This is due in part to the limitations upon the market. Various forms of resistance have been met, such as lack of acceptance by the building public, lack of cooperation on the part of labor, inflexible requirements in building codes, efforts to popularize houses made of but one material, transportation difficulties of shipping the large-sized items at low cost, etc. Because of these obstacles, the companies in the business of producing prefabricated houses of more or less traditional materials have been able to accomplish economies of only about 10 percent so far, compared with ordinary methods; and these small savings are due in large part to quantity purchases.[42]

Pending the overcoming of these obstacles, the future of prefabricated housing is none too bright. It has indeed shown few signs of developing into a great employment-creating industry. As one student of the industry remarks, "Little progress has been made in the last 10 years." [43]

2. *Air-conditioning.*—Considerable advances have been made in air-conditioning in recent years, particularly for use in public buildings, retail stores, movie theaters, restaurants, etc., and it is probable that the future will see an increased use in these fields. Air-conditioning will become a major stimulus to the economy, however, only when

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[40] Temporary National Economic Committee Monograph No. 8, Toward More Housing, Part 1, "Some Economic Aspects of Housing," by Peter A. Stone, 1940, p. 108.

[41] Ibid., p. 108.

[42] Hearings before the Temporary National Economic Committee, Part 11, Construction Industry, pp. 5337, 5338.

[43] Temporary National Economic Committee, Monograph No. 8, op. cit., p. 108.

it reaches the mass market of residential buyers. In the words of Dr. Paul Douglas of the University of Chicago:

Perhaps new housing, television, and air-conditioning are the most promising possibilities, but unless great reductions are made in their costs, these will be out of reach of the incomes of the great masses who alone can create a sufficient demand to make large-scale production profitable.[44]

Certain technical problems have yet to be overcome in developing a product suitable for the residential market. For example, in areas of very low humidity air-conditioning requires a new type of window. Where cold temperatures prevail in the wintertime, double windows are necessary. Though much progress has been made along these lines, wide development of residential air-conditioning remains for the future.[45]

Perhaps no one is better fitted to testify regarding the economic potentialities of these new industries, such as air-conditioning, than the noted inventor and scientist, Charles F. Kettering.

We have heard a lot of talk, we will say, about air-conditioning. Air-conditioning has done a very, very good job, but yet the economics of air-conditioning perhaps haven't reached the point at which it can be of general usefulness. We are trying to find out what we can do to make this thing more flexible, easier to handle, more easily installed, and things like that.[46]

3. *Television.*—Like air-conditioning, television faces technical difficulties before it is ready for general use, chief among which is the problem of transmitting for more than 50 or 100 miles. Even where transmission extends over only a few miles, reception on a set of reasonable cost still leaves much to be desired under most circumstances. With regard to the possibilities of television, Mr. Kettering observed:

Take television as a new industry. It will have to struggle along quite a long while before it strikes its pace, because you can't hit the middle of the road but very rarely, and then it is an accident.[47]

No matter what its future development, television will probably not bring about any considerable net gain in employment since its production and use will undoubtedly involve a large degree of substitution affecting the radio industry.

4. *Diesel engines.*—When asked whether he saw on the horizon any new product which might develop into a great new industry within the next decade, Mr. Kettering replied that aside from the Diesel engine he knew of no new invention or development which promises to stimulate the economy in the next decade as did the automobile, or even the radio, in the twenties.[48]

The Diesel engine not only is a substitute for steam locomotives but diminishes greatly the amount of maintenance and repair labor required in railroad transportation; according to Dr. Isador Lubin.

The Diesel engine makes it possible to keep traffic moving, day after day, year in and year out, without having to have the expensive equipment and the labor force necessary to keep it serviced. I think I read of one the other day that had been in service a year and a month and had been to the shop once. It ran 365 days a year, which makes it possible for one engine to do the work of four, because it can be used four times as long in 24 hours, which is not only labor-

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[44] Paul Douglas, Controlling Depressions, W. W. Norton, New York, 1935, p. 82.
[45] Hearings before the Temporary National Economic Committee, Part 30, p. 16302.
[46] Ibid., p. 16302.
[47] Ibid., p. 16302.
[48] Ibid., 16315.

saving but also capital-saving. You need only one whereas formerly you needed four.[49]

Perhaps today there is some great employment-creating industry on the horizon. Any prediction that new products will not be developed, or if developed cannot be expected to overcome limitations in our economy might prove just as fallacious as the widespread belief that technology, because it has created great new industries in the past, will inevitably continue to do so in the future.

Technological progress is always unpredictable, but in light of the foregoing it seems unlikely that we can rely heavily upon future new industries to offset the labor-displacing effects of technology.

THE REDUCTION OF PRICES

THEORETICAL IMPORTANCE OF PRICE REDUCTIONS

The importance of lower prices as a force to offset labor-displacement rests upon the assumption that price reductions increase demand, thereby expanding output and creating employment. Even the development of a new industry frequently depends upon prices low enough to command a wide market.

The importance of this compensatory force in economic theory can hardly be overemphasized. References to its theoretical importance have already been presented in Part I of this report, "Technology and Economic Thought."

This fundamental tenet of economic thought, that over a long-term period increases in the productivity of labor are reflected in lower prices of commodities, with a resultant increase in production, should be examined. If prices do not decline as productivity increases, this basic principle is either inoperative or the functioning of the present-day economy prevents its operation.

It is not the purpose of this report to undertake an extensive examination of price behavior. Such an analysis can be found in another report of the Temporary National Economic Committee.[51] But there is one element in the determination of price behavior which bears a direct relationship to technology. In recent years, the possible existence of a relationship between the concentration of economic power and price inflexibility has been frequently examined. For example, a recent study of the National Resources Committee stated:

> The main conclusion to be reached from this analysis is that, while many factors influence price insensitivity the dominant factor in making for depression insensitivity of prices is the administrative control over prices which results from the relatively small number of concerns dominating particular markets.[52]

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[49] Ibid., p. 17248. While it is true that Diesel engines already have definite application where relatively large power units are required, they have not yet been proved practicable for general use in the lighter cars. In some quarters, moreover, it is believed that the extra cost for efficient Diesel units for small cars will more than offset the fuel savings that they achieve. (U. S. Bureau of Labor Statistics, Monthly Labor Review, June 1940, "Employment Prospects in the Petroleum and Natural-Gas Industry," by H. O. Rogers, p. 1301.)

[51] Temporary National Economic Committee Monograph No. 1, Price Behavior and Business Policy, 1940.

[52] National Resources Committee, The Structure of the American Economy, Part I. p. 143, 1939.

Certain economists have pointed out that centralized industries do not reflect the declines in prices necessary to stimulate production and thus offset the effects of increasing productivity of labor. If a relationship exists between concentration and price stability and in turn between technology and concentration, then technology itself would be an obstacle to the functioning of the basic compensatory force of price reductions.

The next chapter examines the relation between technology and concentration but of pertinence here is an analysis of the behavior of labor productivity and industrial prices in concentrated and nonconcentrated industries.

Industrial Prices and Labor Productivity.

To ascertain whether or not labor-displacement has been offset by price reductions, a study was made of the relationship between the behavior of labor productivity and of prices in nine major industries. The industries have been separated into two groups, concentrated and nonconcentrated, the principal standard of delineation being the percent of the industry's output produced by its four largest firms. Durable and nondurable goods industries are represented in each group, as are both producers' goods and consumers' goods industries in the concentrated group. A detailed analysis of productivity and prices in each industry will be found in appendix H. General conclusions will suffice at this point.

In that analysis the increasing productivity of labor and the rigidity of industrial prices are not regarded as separate phenomena. Rather, it is important to discover whether the industries which have been characterized by inflexible prices also have benefited from extensive technological savings on labor expenditures.

The National Research Project, in its study of 59 manufacturing industries, found only one which was not characterized by a marked long-term decline in unit labor requirements, the bakery products (other than biscuits and crackers) industry.[53] The possibility that prices in certain industries have fallen only partially as much as unit labor requirements therefore needs exploration.

A summary comparison of the productivity-price relationship of a concentrated industry with that of a nonconcentrated industry is made in chart XIV, which contrasts the behavior of the unit labor requirement and price indexes in the cement industry with the behavior of the indexes in the furniture industry. In general, these two industries may be regarded as typical of the two groups.

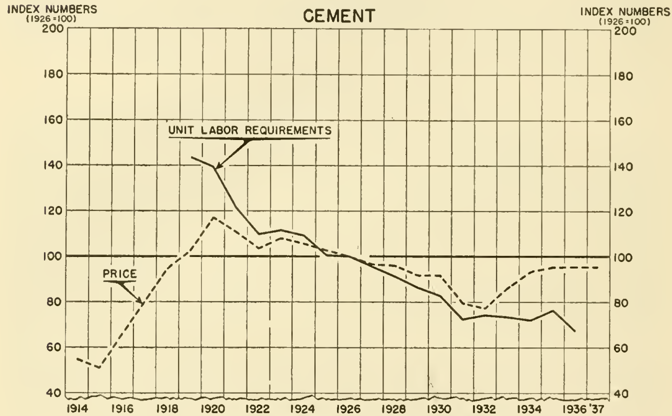
The price indexes in the concentrated industries tend to remain well above their pre-war position, while the price series of the nonconcentrated industries closely approach the 1914 level. The unit labor requirement series tend to drop more extensively than price since 1919 in the concentrated industries, while the two series tend to parallel each other in the nonconcentrated industries, with the price series often evidencing, for sustained periods, a decline more extensive than that of the unit labor requirement index. This difference in the type of relationship is graphically apparent in the comparison between the cement and furniture industries and also characterizes the other

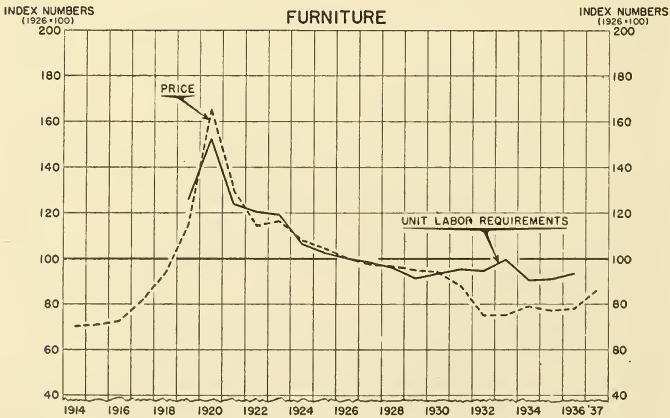
[53] Works Progress Administration, National Research Project, Production, Employment, and Productivity in 59 Manufacturinng Industries, 1919–36. (By nnit labor requirements is meant the number of man-hours required to produce a given amount of goods.)

Chart XIV

INDEXES OF UNIT LABOR REQUIREMENTS AND PRICES

UNITED STATES





Source: Appendix H, Tables 4 and 11.

concentrated industries—iron and steel, nonferrous metals, automobiles, cigarettes, electric light and power—as well as the two other nonconcentrated industries, cotton and woolen goods.

The tendency of unit labor requirements to decline more extensively than price in the concentrated industries naturally varies in degree and in time among them. It was most noticeable in the iron and steel industry during 1919–29 and again during 1933–37. In the nonferrous metals industry, it continued throughout the entire period, except for brief interruptions in 1931–32 and 1934–35.[54] In the motor vehicles industry, the price series declined considerably more than unit labor requirements from 1921 to 1923. During the periods 1919–21, 1923–30, and 1933–37, however, the tendency was reversed.[55] In the cigarette industry, the general decline in unit labor requirements throughout the entire period was far greater than any decrease in price, except for 1933–34.[56] The over-all decline in unit labor requirements in the electric light and power industry was materially greater than the decrease in price, despite the relatively large expenditures of man-hours during the twenties involved in the installation of new light and power facilities.[57]

In rather sharp contrast, the unit labor requirement index in the nonconcentrated industries seldom declined more extensively than the price series. In the cotton goods industry, the two indexes tended to parallel each other during 1920–30. During 1932–34, the price series turned upward from its depression low, but in the following two years declined with the unit labor requirement index. The productivity-price relationship in the woolen and worsted goods industry parallels almost exactly that of the cotton goods industry except for the last two years. In the furniture industry, the two indexes moved closely together until 1930, after which the price series fluctuated moderately at a level well below that of the unit labor requirement index. In the cement industry, however, the unit labor requirement index, as noted, fell considerably more than the price index for practically the entire period, 1919–36.

Perhaps of greatest pertinence to the contemporary unemployment problem is the divergence of trends between unit labor requirements and prices since 1929. The enlargement of the spread may be attributed to the upturn of prices from the depths of 1932–33 which took place from 1934 to 1937. By 1937 the price series in the concentrated industries (except in the electric light and power industry) had risen to levels only slightly below, and in some cases actually above, the 1929 levels. But the unit labor requirement series turned sharply downward after 1933, following its rise in the worst years of the depression because of curtailment of output, reaching an all-time low by 1936 (except in nonferrous metals).[58]

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[54] The tendency of unit labor requirements to rise in periods of greatly curtailed output, such as 1930–33, should not generally be interpreted as invalidating the long-term downward trend. The period of greatly curtailed output in the nonferrous metals industry after 1930 was extended partly because of the price-pegging activities of the industry during 1929–30 and the resultant creation of enormous stocks. (For further discussion see pp. 247–250, infra.)

[55] See p. 259, infra.

[56] See p. 263, infra.

[57] See p. 269, infra.

[58] It should be noted that, although the unit labor requirement series extend only to 1936, the indexes would undoubtedly be at lower levels in the more prosperous year of 1937 because of the tendency of man-hours per unit to decline as output increases.

It is apparent that the relative nonuse of the technique of price reductions in the concentrated industries as a means of meeting the unemployment problem created by declining unit labor requirements has become particularly acute in recent years. The extensive decreases in unit labor requirements in these industries have created an unemployment problem met only to a very limited extent by any increases in production which can be attributed to reductions in prices. Industrial prices, by remaining comparatively stable in the face of marked declines in unit labor requirements, cannot have played an effective role in meeting the unemployment problem created by technological change, and as long as they maintain that relative stability their importance as a compensatory force must be regarded as negligible.

The first of the two steps required to discover whether or not technology tends to lead to the negation of one of its own compensatory forces has thus been presented above in the summation of the relationship between concentration and price stability. The second step is presented in the following chapter, which is concerned with the possible existence of a relationship between technology and concentration.

CHAPTER IV

TECHNOLOGY AND THE CONCENTRATION OF ECONOMIC POWER

THE CONCENTRATION OF INDUSTRY

One of the outstanding developments in American industry is the growth in the concentration of economic power. Economic concentration connotes the existence of large units of production, of vast corporate enterprises producing large quantities and often a striking variety of goods, of industrial empires owning and controlling materials, equipment, and processes from the extraction of raw materials to the distribution of finished products, of dominance over an entire industry by a small number of giant concerns, and frequently of policies pursued by these concerns designed to minimize the existence of price competition. Concentration is a problem of vital importance to the Nation, particularly because technology steadily increases the power at the command of giant concerns by creating new tools, processes and products.

A high degree of concentration exists in many segments of our economy and is rapidly growing in others. Even in agriculture concentration is a growing phenomenon. The extent of concentration in manufacturing has been statistically measured by determining the proportion of the total output produced by the four largest concerns manufacturing a given commodity. Wherever the four largest producers manufacture over half the entire output of a given commodity, a high degree of economic concentration, by almost any standard, has evidently been established.

The degree of concentration in all manufacturing in 1935 is shown in table 23 by physical number of products and by value of products.

Industries in which the four largest concerns make over 75 percent of the total number of manufactured products account for 39.4 percent of the total number and 25.9 percent of the total value of manufactured products, while industries in which the four largest concerns make over 50 percent of the total number of manufactured products account for 71.9 percent of the total number and 54.4 percent of the total value of manufactured products.

Other indications of concentration were cited by the President of the United States in his message to Congress April 20, 1938:

> Statistics of the Bureau of Internal Revenue reveal the following amazing figures for 1935:
>
> Ownership of corporate assets: Of all corporations reporting from every part of the Nation, one-tenth of 1 percent of them owned 52 percent of the assets of all of them.
>
> And to clinch the point: Of all corporations reporting, less than 5 percent of them owned 87 percent of all the assets of all of them.
>
> Income and profits of corporations: Of all the corporations reporting from every part of the country, one-tenth of 1 percent of them earned 50 percent of the net income of all of them.
>
> And to clinch the point: Of all the manufacturing corporations reporting, less than 4 percent of them earned 84 percent of all the net profits of all of them.[1]

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[1] 75th Cong., 3d sess., S. Doc. 173, Strengthening and Enforcement of Antitrust Laws, p. 2.

TABLE 23.—*Percent of number and value of products manufactured by 4 largest concerns,*[1] *1937*

Percent produced by 4 largest concerns	Products			Value of products		
	Number	Percent	Cumulative percent	Amount (thousand dollars)	Percent	Cumulative percent
0.1 to 5.0	1	(2)	(2)	353,432	1.2	1.2
5.1 to 10.0	7	0.4	0.4	357,663	1.2	2.4
10.1 to 15.0	10	.6	1.0	477,592	1.6	4.0
15.1 to 20.0	28	1.5	2.5	792,708	2.7	6.7
20.1 to 25.0	44	2.4	4.9	1,454,942	5.0	11.7
25.1 to 30.0	46	2.6	7.5	1,304,025	4.4	16.1
30.1 to 35.0	54	3.0	10.5	1,421,494	4.8	20.9
35.1 to 40.0	69	3.8	14.3	2,892,890	9.8	30.7
40.1 to 45.0	91	5.0	19.3	1,461,146	4.9	35.6
45.1 to 50.0	75	4.2	23.5	2,060,290	7.0	42.6
50.1 to 55.0	85	4.7	28.2	893,227	3.0	45.6
55.1 to 60.0	98	5.4	33.6	1,761,698	6.0	51.6
60.1 to 65.0	100	5.5	39.1	1,287,529	4.4	56.0
65.1 to 70.0	130	7.2	46.3	1,445,246	4.9	60.9
70.1 to 75.0	124	6.8	53.1	1,689,270	5.7	66.6
75.1 to 80.0	135	7.5	60.6	2,224,582	7.5	74.1
80.1 to 85.0	117	6.5	67.1	1,449,834	4.9	79.0
85.1 to 90.0	101	5.6	72.7	648,389	2.2	81.2
90.1 to 95.0	75	4.2	76.9	2,796,032	9.5	90.7
95.1 to 100.0	89	4.9	81.8	319,819	1.1	91.8
(3)	153	8.5	90.3	1,827,858	6.2	98.0
(4)	175	9.7	100.0	586,027	2.0	100.0
Total	1,807	100.0	----------	29,505,693	100.0	----------

[1] The data represent approximately one-third of all manufacturing industries; in nearly every case all of the products of the industries studied were covered. In an endeavor to make the sample representative an attempt was made to establish a balance between industries with a large and those with a small number of concerns, and between industries with a high and those with a small value of products. The sample included one-third of all industries within each of the census industry groups, with the exception of printing and publishing. The last 2 frequency groups, involving possible disclosure of individual companies, represent concentration ratios of over 85 percent.

[2] Less than 0.1.

[3] Withheld to avoid disclosing the operations of individual companies.

[4] Withheld to avoid disclosing the operations of remaining companies. There is not necessarily a disclosure among the 4 leading companies.

Source: Temporary National Economic Committee Monograph No. 27, The Structure of Industry, Part V, "The Concentration of Production in Manufacturing," table 1.

Technology is undoubtedly one of the primary causes of this concentration. For example, the United States Tariff Commission in 1939 observed concerning the manufacture of electric lamp bulbs:

There were five manufacturers of bulbs in the United States in 1917, and there have been only two making large bulbs since 1920. This concentration in output was due in part to the fact that the most economical production was possible only in highly mechanized plants of very large capacity, and in part to the control which owners of patents have exerted over production.[2]

The greater operating efficiency of large units of production stems from technology. Likewise, the control exerted by means of patents stems from technological developments which under our law may be patented. The relation of the operating efficiency of large units, of large industrial research organizations, and of patents to concentration will be analyzed in this chapter.

[2] U. S. Tariff Commission. Incandescent Electric Lamps, Rept. No. 133, Second Series, 1939, p. 19. It should continuously be borne in mind that the causes of concentration, both direct and indirect, are numerous and varied; and of them, technology is but one. The occurrence of mergers and consolidations, as one example, has been due in many cases to the prospect of profit making through security speculation in the concerns involved, rather than to any technological advantage to be derived therefrom.

CONCENTRATION AND OPERATING EFFICIENCY

The determination of whether or not technological development leads to the concentration of economic power rests first upon an examination of the relative efficiency of large-scale and small-scale operations in producing under similar conditions a certain number of units of a given commodity. Though such a comparison is impossible with existent data, certain types of analyses should cast considerable light upon large-scale versus small-scale operation.

All discussions of relative efficiency of large and small units must not lose sight of the existence of a point of diminishing returns in any productive process since there is obviously a point beyond which large-scale operation results in increased rather than decreased unit costs. Even though there is at present no adequate statistical method of determining where that point occurs, it is still possible to discuss in general terms the relative efficiency of large-scale equipment as against small-scale equipment.[3]

The use of large-scale equipment is advantageous because it generally results in (1) "smaller capital outlay per unit of capacity," (2) "greater mechanical efficiency," (3) "the use of a considerably smaller amount of fuel and also of labor per unit of capacity or of output," (4) smaller floor space requirements and thus less plant construction per unit of capacity, (5) lower transportation costs per unit of capacity, and (6) "the use of refinements and of auxiliary devices which result in improved efficiency of operation."[4]

Three theoretical principles have been advanced by Prof. P. Sargant Florence in support of the contention that—

> *large-scale production, especially when conducted in large-scale firms and plants, results in maximum efficiency.* * * * The Principle of Bulk Transactions. * * * The total monetary, physical or psychological costs of dealing in large quantities is sometimes no greater (and in any case less than proportionately greater) than those of dealing in small quantities; and hence the cost per unit becomes smaller with large quantities. * * * The Principle of Massed Reserves. * * * The reserves that are economized may in fact be labor, liquid monetary resources, stocks of goods and materials, or any other factors in production, when the demand upon these factors are somewhat uncertain in their incidence. * * * This * * * is merely [in economic application] * * * the statistical theory of probable error that the greater the number of items involved the more likely are deviations in their amounts to cancel out and to leave the actual result nearer to the expected result. The probable deviation in orders for similar items that a reserve guards against is thus proportionately less when orders are many, and the cost of reserves per unit of output fails correspondingly. The Principle of Multiples. * * * The smaller the scale of operation and the fewer the total number of persons dividing and diffusing their labor, the less chance there is of all of them being fully made

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[3] It should be clearly understood that this analysis does not relate to that centralization of economic power resulting from associational activities. As far as horizontal agreements of any kind are concerned, there is little evidence that their existence raises the operating efficiency of member units materially. Dr. Arthur Lucas, in his study of British experiments in the control of competition, has observed:

"It does not appear that the terminable association can claim much credit for its ability to increase the efficiency of an industry's productive organization. * * * The chief economies in this field arise out of the concentration of processes, the specialization of function, the scrapping of inefficient equipment, and the unification of management. Except in rare cases it is not possible to introduce these measures to an important degree without a stronger organization than most associations possess." (Arthur F. Lucas, Industrial Reconstruction and the Control of Competition—The British Experiments, Longmans, Green & Co., London, 1937, p. 318.)

[4] Works Progress Administration, National Research Project, Effects of Current and Prospective Technological Developments Upon Capital Formation, by David Weintraub, 1939, p. 5.

use of as specialists. * * * Suppose that an article is being manufactured by subjection to 3 consecutive processes, the first a hand-process where a specialist can make 30 units a week, the second an automatic machine process where 1,000 units can be made in a week, the third a semi-automatic machine process where 400 units can be made per week. Then to employ all the specialists and special machines fully a number of units must be made per week that is a multiple of 30, 400, and 1,000; otherwise some man or machine will be partly idle. In this case the lowest common multiple number of units that will employ specialists in all processes to full capacity is 6,000. * * * Clearly this assumes large-scale production * * *.[5]

It should not be thought, however, that large-scale operation is invariably the most efficient. The extent of its efficiency varies with the *circumstances of production.* Certain types of productive operations readily lend themselves to the use of large-scale equipment; others can be more efficiently carried out with small-scale equipment. For example, continuous process industries, such as steel, chemical, cement, flour, etc., are so organized that highly specialized, large-capacity handling equipment is generally extremely effective in reducing costs per unit of output. Such equipment requires large capital outlays and its costliness in turn gives impetus to concentration in order to achieve maximum use. On the other hand, the efficient handling of materials in a clothing factory, knitting mill, or job machine shop can usually be performed by a small gravity or belt motor, storage conveyor, or industrial truck. Such handling equipment involves relatively small capital outlays and imparts little impetus to concentration.

In some fields of production, highly flexible and adaptable techniques have been developed which place a premium upon small-scale rather than large-scale equipment. In the southern lumber industry, for example, the introduction of mobile and flexible logging equipment, such as tractors, trucks, and gasoline skidders, has made it possible to obtain timber from stands which could not have been logged profitably with the old type of larger and less flexible equipment.

The operation of small mills on timber from second-growth stands or scattered old-growth stands has been made more profitable by the adoption of flexible mechanical logging equipment, particularly trucks. * * * The use of trucks as a substitute for or as a supplement to railroads and the use of tractors and gasoline donkeys in place of heavy steam cable yarders have increased the chances for profitable operation of a system of selection logging.

The efficiency of these small-scale techniques has resulted in a replacement of old-type mills with large-scale equipment by smaller mills. This replacement has proceeded farthest in pine lumber production, and to a lesser extent in hardwood production.[6]

The use of the most efficient techniques of production in the southern lumber industry apparently accelerates decentralization rather than concentration. This is true for a limited number of resource-extracting industries in which the receding of the resources places the large but stationary producing unit at an obvious disadvantage.

On the other hand, a number of diversified industries exemplify the way in which the greater efficiency of large-scale equipment has contributed to the growth of economic concentration.

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[5] P. Sargant Florence, The Logic of Industrial Organization, Kegan Paul, Trench, Trubner & Co., Ltd., London, 1933, pp. 11–20.

[6] Work Projects Administration, National Research Project, Mechanization in the Lumber Industry, by A. J. Van Tassel and D. W. Bluestone, 1940, pp. 105–107.

(1) In the iron and steel industry, for example, the automatic strip mills (described elsewhere in this report)[7] represent the most efficient type of rolling mill technique.

These expensive mills, which smaller companies operating the obsolete hand-mills cannot afford to install, are further concentrating the control of steel producing facilities in the hands of fewer and larger companies. In the steel industry at present there are 18 small independent companies with obsolete hand-mills. * * * These companies employ a total of 23,350. Their combined capacity for flat rolled products is 2,350,000 tons, or 15 percent of the industry's hand mill capacity in 1929 for plates, sheets, black plate, or tin plate.

Daily they are losing business to the strip mill producers, and before long their entire business will have been gobbled up by the huge strip producers, and these small independent companies will have closed their doors for all time. * * *

These companies are doomed, because their obsolete mills depend, in the main, upon manual power; while the automatic strip mills derive their power primarily from electricity. The difference in the cost of production is fatal to the smaller companies. Men cannot compete against electricity. * * *

The economic effects of the strip mills, therefore, are the elimination of the smaller companies and the further concentration of steel-producing facilities in the hands of the few large steel companies. The new steel technology is accentuating monopoly in the steel industry.[8]

The large units and elaborate equipment required in the iron and steel industry involve heavy capital outlays.

A modern blast furnace of about 1,000 tons capacity * * * (with ordinary) auxiliary equipment * * * costs four to five million dollars. The average investment required for a modern steel works of efficient size is approximately $100,000,000. Such a mill would be capable of producing about 1,000,000 tons of ingots per annum and would have diversified finishing equipment of sufficient capacity to convert about half the output into billets and other semi-finished steel and the other half into sheets and strip. Such an investment would not include operations prior to the assembly of raw materials at the plant site, i. e., the plant would be integrated only from coke plant to continuous rolling mills. Operating units may be and sometimes are much larger; a single continuous hot and cold rolling finishing plant alone may require an investment of $60,000,000.[9]

(2) In nonferrous metals the tendency is the same; the greater efficiency of large-scale equipment has been of the utmost importance in the concentration of economic power. Ore extraction has shifted markedly away from small-scale operations on high-grade ore to mass-production techniques on low-grade ore, particularly in copper. Since many of the largest low-grade deposits lie close to the surface, the highly efficient open-cut or surface method of operation has been increasingly used. "The initial advantages of the surface mines were increased further by continuous technical advances, such as the evolution of the large-size electrified power shovel and associated machinery."[10]

The open-cut method has considerably reduced the cost of producing copper. Based on the 1926–30 average, the direct mining cost by the open-cut method was 2.26 cents per pound of recoverable copper compared with 4.10 cents by caving methods and 4.53 cents for all underground mines.[11] The introduction and use of the highly efficient open-cut process requires huge capital outlays which small producers cannot

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[7] See pp. 111–112, supra.

[8] Hearings before the Temporary National Economic Committee, Part 30, p. 16470.

[9] Hearings before the Temporary National Economic Committee, Part 26, Iron and Steel Industry, Exhibit 1410, Some Factors in the Pricing of Steel, prepared by the U. S. Steel Corporation.

[10] Works Progress Administration, National Research Project, Mineral Technology and Output Per Man Studies, Grade of Ore, by A. V. Corry and O. E. Kiessling, 1938, pp. 49–50.

[11] Work Projects Administration, National Research Project, Technology, Employment and Output Per Man in Copper Mining, 1940, p. 23.

afford. Furthermore, improved mining methods have been of much greater benefit to large producers of low-grade ores than to small operators. During the twentieth century, therefore, the expansion of the copper-mining industry has coincided with the concentration of the productive facilities of the industry in the hands of three large producers, the Anaconda Copper Mining Co., the Kennecott Copper Corporation, and the Phelps Dodge Corporation, each of which is integrated vertically from mine to consumer. The growth of economic concentration in copper mining is shown in the following table:[12]

Company	Percent of total mine production of copper		
	1922	1929	1936
Anaconda Copper Mining Co.	22.3	20.6	20.3
Kennecott Copper Corporation	4.7	16.6	31.9
Phelps Dodge Corporation	7.6	9.1	21.8
Total	34.6	46.3	74.0

The shift from selective mining of high-grade ore to mass mining of low-grade, widely disseminated deposits was in part made possible by technological advances in a milling process. The development of the selective flotation process has in turn tended to increase economic concentration since the milling of non-ferrous metals in large central plants effects reductions in labor cost of from 4 to 15 cents per ton and at the same time increases the efficiency of metal recovery. "Thus better concentration, made possible by larger and more efficient mills, not only increases the operator's margin from ores of existing grade, but also permits the more wide-spread working of lower yielding metal."[13]

The greater efficiency of large plants in the milling of nonferrous metals is apparent in table 24, which compares man-hour requirements per ton in plants of different size.

(3) The cement industry affords another example of the greater efficiency of large-capacity equipment. The rotary kiln has grown in average length from 25 feet in 1890 to 146 feet in 1935. In 1925, 56 of the 810 kilns in the industry were 200 feet or more in length. By 1935 there were 119 such kilns out of a total of 823. Today some of the most modern kilns are over 400 feet in length.[14]

> The growth in the capacity of kilns has tended to reduce capital investment per barrel of capacity. This has been brought about by the elimination of multiplicity of feeding, driving, and fuel-preparing equipment and the reduction in floor area, foundations, and other items contributing to greater installation costs when a large number of small kilns are used.
>
> The growth in kiln capacity has also given rise to a number of operating economies. * * * Larger units do not require additional labor for their operation. Reduction in labor requirements has resulted also from a decrease in maintenance costs achieved through the use of superior refractory materials * * *.
>
> Nor should economies in the consumption of fuel be overlooked; the longer the kiln, the more the materials can absorb heat from the products of combustion.

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[12] Ibid., p. 20.

[13] Works Progress Administration, National Research Project, Mineral Technology and Output Per Man Studies, Grade of Ore, pp. 78–79.

[14] Works Progress Administration, National Research Project, Fuel Efficiency in Cement Manufacture, 1909–35, 1938, p. 39

In this way the temperature of the stack gases is lowered and the loss of heat through the stack is reduced. The final result is a diminution of fuel requirements per barrel of cement. For example, the 60 to 80-foot kilns which were in general use until 1910 consumed about 100 to 150 pounds of coal per barrel of cement, whereas modern 250- to 300-foot kilns consume less than 100 pounds of coal per barrel, and kilns over 350 feet long consume as little as 70 to 80 pounds of coal per barrel.[15]

(4) In the brick and tile industry certain large-scale techniques have been of considerable importance in bringing about concentration. Among these is the autobrick machine which performs "mechanically the work of sanding the mold, striking off the excess clay, and bumping the mold to loosen the formed clay, so that the labor associated with its operation was about 50 percent of that required by the nonautomatic equipment.[16] It is significant that these machines are installed principally in the larger plants.

TABLE 24.—*Milling of nonferrous metals,[1] differences in man-hour requirements per ton in plants of different size according to normal output*

	7 tons an hour	17 tons an hour	40 tons an hour	208 tons an hour
Crushing	0.1040	0.1015	0.0374	0.0235
Grinding	.0995	.0768	[2].0374	.0141
Concentration, gravity			.1496	.0141
Flotation	.3125	.0768	.0748	.0094
Dewatering concentrates	.0994	.0768	.0374	.0047
Samplings	.0957	.0256		.0047
Tailings disposal	.0762	.0512	.0374	
Miscellaneous [3]	.1180	.1536	.0374	.0361
Total labor	.9053	[4].6135	.4114	.1066

[1] Table refers specifically to lead and zinc, but similarity of processes relates it also to copper.
[2] Includes 0.0187 for classification and screening.
[3] Includes supervision, maintenance, warehouse, power, etc.
[4] Includes 0.0512 for weighing and loading.

Source: Adapted from U. S. Bureau of Mines, Bulletin 381, Lead and Zinc Mining and Milling in the United States, 1935, p. 190.

The National Research Project has made a comparison of unit labor requirements for small, medium-sized, and large plants manufacturing brick and tile. "Plants with a capacity of less than 15,000,000 brick per year were classified as small, while those of 30,000,000 brick or over were classified as large." The plants in the study were separated by type of process—stiff mud, soft and other processes.

For all processes combined the average standard man-hour ratios are highest for small plants, the average being 11.48, and lowest for large plants, the average being 6.87 * * *. In other words, 40 percent less labor is used to produce 1,000 brick in large plants than in small plants; the same relationship holds for each process; that is, the large plants have the smaller man-hour ratios, and the smaller plants have the larger man-hour ratios. There is one exception in soft-mud plants, when small- and medium-sized plants are compared, but this is doubtless due to the fact that there are so few plants in these classes.[17]

This comparison of man-hour requirements by size of plant is shown in table 25.

[15] Work Projects Administration, National Research Project, Mechanization in the Cement Industry, 1939, p. 54.
[16] Works Progress Administration, National Research Project, Productivity and Employment in Selected Industries, Brick and Tile, by Miriam E. West, 1939, p. 91.
[17] Ibid., p. 120.

TABLE 25.—*Average standard man-hour ratios for sample brick and tile plants, by capacity and process* [1]

Process	All plants		Annual capacity (millions of common-brick equivalents)					
			Less than 15		15–29.99		30 or over	
	Ratio	Number of plants	Ratio	Number of plants	Ratio	Number of plants	Ratio	Number of plants
All processes	9.66	69	11.48	22	9.82	29	6.87	18
Stiff-mud	9.67	55	12.40	14	9.66	25	6.99	16
Soft-mud	10.33	9	10.74	4	12.73	3	5.91	2
Sand-lime and dry-press	8.27	5	9.03	4	5.23	1	--------	0

[1] Includes all plants for which standard man-hour ratios could be calculated.

Source: Works Progress Administration, National Research Project, Productivity and Employment in Selected Industries, Brick and Tile, 1939, p. 120.

Many more examples of industries could be given in which the greater efficiency of large-scale equipment has led to concentration because of the large capital outlays required to purchase such equipment.[18] This type of cumulative evidence, however, should be supplemented by a statistical analysis for a larger number of industries of the relationship between technological efficiency and concentration. Such an examination is made in the next section.

THE MEASUREMENT OF TECHNOLOGICAL EFFICIENCY

One measure of the degree of efficiency in different sized plants in a given industry is the amount of electrical energy (either purchased or generated in the plant) consumed per man-hour. This measure is usable because the tendency, especially in recent years, in the creation of new and improved mechanical techniques of production has been in the direction of developing those that are electrically powered. From 1919–29 the increase in power capacity of American industry was accounted for almost entirely by the increased use of electricity; according to the Census of Manufactures:

[18] For example, "In the flour-milling industry the cost per unit of capacity of a roller mill with an hourly capacity of 50 bushels is twice that of a larger mill with a capacity of 115 bushels." Reflecting the greater efficiency of this large-scale equipment, the average size of roller mills in the flour-milling industry introduced in the years 1930–34, was approximately 22 percent higher than that of those introduced in 1920–24. "The cost of spiral screw conveyors used in flour mills declines from $2.83 per unit of capacity (100 bushels per hour per foot), on small conveyors with a capacity of 60 bushels per hour per foot, to $0.23 as the capacity is raised to 1,000 bushels per hour per foot, and to $0.10 for conveyors of capacity of 4,500 bushels per hour per foot." (Works Progress Administration, National Research Project, Effects of Current and Prospective Technological Developments upon Capital Formation, p. 4.)

In the field of power, "a report of the Federal Power Commission shows that steam-power units installed in central stations during the period 1931–34 averaged over 30,000 kilowatts in capacity as against approximately 15,000 kilowatts per unit in 1931–35. The original investment per unit of capacity is a great deal smaller for large steam-electric generating stations than for small ones, ranging from $135 to $150 per kilowatt for stations of a capacity of 2,000 kilowatts to $92 to $115 per kilowatt for stations of 200,000 kilowatts. The cost per unit of capacity in the case of boilers capable of producing 1,000,000 pounds of steam per hour is less than one-half that of a boiler with one-tenth that capacity. Likewise, in Diesel plants investment per unit of capacity varies inversely with the capacity, declining from $230 to $106 as the capacity increases from 100 to 10,000 kilowatts." (Ibid., pp. 3–4.) And in electric motors, "The price per horsepower of 500 revolutions per minute Westinghouse motors of the squirrel cage type declines from $9.30 for a motor of 250 horsepower capacity to $6.20 for a motor of 1,000 horsepower; for motors of the wound-rotor type the price declines from $12.00 to $7.80 as the capacity is thus increased." (Ibid., p. 4, footnote 11.)

The combined horsepower of steam engines and turbines, internal-combustion engines, and water wheels and turbines, for all industries, has not varied materially from census to census since and including that for 1919, whereas the power of electric motors has increased rapidly. In other words, during the past decade the increase in the aggregate primary power is accounted for almost exactly by the increase in the power of electric motors driven by purchased energy.[19]

The more modern and efficient types of technological equipment are primarily those driven by electrical power, and the amount of electrical energy per man-hour used by plants of varying sizes within a given industry indicates roughly the extent to which they use electrically-powered techniques of production.[20] Granted the greater efficiency of machinery designed for electrical motivation and control, the amount of electrical energy consumed per man-hour in plants of different size within a specific industry therefore affords a criterion of their relative efficiency.

It should be pointed out that the calculation of electrical energy used per man-hour does not indicate the relative efficiency of one industry compared with another. Nor does it indicate that any particular size of plant has more electrically-powered machinery than plants of other sizes. Its purpose is to relate the use of electrically-powered equipment to the unit of labor expenditure, the man-hour, for plants of varying size in the same industry.

The Bureau of Labor Statistics has calculated the amount of electrical energy used per man-hour for 105 manufacturing industries from data gathered by the 1937 Census of Manufactures.[21] Total employment in those 105 industries amounted to 4,161,934 wage-earners in 1937 compared with a total for all manufacturing industries of 8,569,231 wage-earners. The industries were widely scattered among the major fields of food and tobacco, textiles, chemicals, stone, clay, and glass, and metals. For many of the industries, breakdowns by size of plant were made. Thus it is possible to make comparisons of electrical energy used per man-hour in plants of varying size.

Chart XV (table 26) graphically shows that in 21 diversified industries electric energy consumed per man-hour—which may be assumed to vary directly with the use of the more modern productive techniques—increased generally with the size of the plants.

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[19] U. S. Bureau of the Census, Census of Manufactures, 1929, vol. 1, pp. 8–9.
For the years 1929–37 it is of interest to note that whereas in the latter year industrial production as reported by the Federal Reserve Board was 7.6 percent below the level of the former year sales of electrical energy to "Commercial large light and power" users (excluding municipal street lighting, etc., and electric railways), as reported in the 1940 Annual Statistical Number of Electrical World, were higher by 24.6 percent.

[20] "The * * * present-day period is characterized by the increasing fusion of the electric motor with the manufacturing equipment, by the creation of an electrical machine in the true sense of the term. The electric motor is no longer an outsider as regards the manufacturing machine to which it supplies the motive power. It penetrates into the parts of the machine, becoming an inseparable part of it, constructively combined with it, directly affecting the character of the machine and of the production processes. Thus the whole of the production process becomes, as it were, the function of the electric motor." (Walter N. Polakov, The Power Age, Covici-Friede, New York, 1933, p. 101.)

[21] U. S. Bureau of the Census, Census of Manufactures, 1937, Man-Hour Statistics for 105 Selected Industries. All other data in this section relative to electric energy per man-hour are derived from this source.

Chart XV

RELATIONSHIP BETWEEN SIZE OF PLANT AND ELECTRIC ENERGY USED (KWH) PER MAN-HOUR

21 MANUFACTURING INDUSTRIES
UNITED STATES, 1937

Source: Table 26.

TABLE 26.—*Electric energy used, kilowatt-hours per man-hour, by size of plant, 21 manufacturing industries, 1937*

Industry	Number of wage earners per plant						
	1–5	6–20	21–50	51–100	101–500	501–2,500	Over 2,500
Flour and other grain-mill products	3.14	5.56	10.82	11.77	[1] 17.11		
Cereal preparations	1.35	1.49	2.82	3.80	7.39	9.53	
Petroleum refining	4.08	4.44	8.29	7.93	13.60	17.29	20.20
Feeds, prepared, for animals and fowls	3.25	3.84	4.90	5.40	7.84		
Lime	.75	2.23	3.94	3.84	5.92		
Glass		[2] 1.98	2.25	1.92	3.66	[3] 6.86	
Aluminum products	.67	.86	1.39	1.23	2.32	[3] 5.16	
Nonferrous-metal alloys; nonferrous-metal products, except aluminum	.81	.85	1.44	1.94	3.29	5.73	5.34
Wrought pipe, welded and heavy-riveted [4]	.26	2.23	1.23	2.25	4.64	4.40	
Insecticides and fungicides, and industrial and household chemical compounds	.65	1.13	1.53	2.28	1.75		
Soap	.80	1.41	1.28	2.96	4.45	3.77	
Steel barrels, kegs, and drums	.78	.94	1.11	2.32	[1] 1.70		
Tin cans and other tinware	1.29	1.13	.99	1.37	1.58	1.66	
Stamped and pressed metal products; enameling, japanning, and lacquering	1.05	.84	.90	1.16	1.71	2.75	
Wirework	.62	.73	1.02	1.06	[1] 1.56		
Electrical machinery, apparatus, and supplies	1.61	1.01	1.35	2.48	1.86	3.12	3.53
Machine tools	.62	.99	.96	1.00	1.30	[3] 1.41	
Machine-shop products	.98	1.15	1.36	1.76	2.46	[3] 2.66	
Engines, turbines, water wheels, and windmills	1.10	.74	.77	1.30	1.61	[3] 2.27	
Refrigerators and refrigerating and ice-making apparatus	.55	.56	.85	1.10	1.66	3.34	2.78
Motor-vehicle bodies	.63	.53	.68	.61	1.00	1.94	2.01

[1] From 101 to 2,500 wage earners.
[2] From 1 to 20 wage earners.
[3] More than 500 wage earners.
[4] Made in plants not operated in connection with rolling mills.

Source: U. S. Bureau of the Census, Census of Manufactures; 1937, Man-Hour Statistics for 105 Selected Industries, table 3, pp. 11–75.

In certain of the industries (for example, petroleum refining) the trend in the amount of electric energy used per man-hour is strikingly upward but in others (for example motor vehicle bodies) the increase is more gradual. In the latter group, however, the nature of the productive process is such that the amount of electric energy used per man-hour is relatively small, and therefore the actual increase would inevitably be less precipitous. But in terms of percentage, the large plants within an industry in this latter group may have a decided advantage over the smaller plants. Thus the difference in the amount of electric energy used per man-hour by the largest and smallest plant size groups in the motor vehicle bodies industry is only 1.38 kilowatt-hours, but by percentage it is 219.[22]

A further indication of the advantages held by the plants which used the greatest amount of electric energy per man-hour is the fact that industries in which the largest plants used the most electric energy also employed the bulk of the labor force.

[22] It should not be forgotten that this advantage refers to the production and not the distribution of goods.

Number of wage-earners in industries in which electric energy used per man-hour is highest

In plants employing—	Employment [23]	Percent of total
1 to 50 wage-earners	347, 127	8. 6
51 to 100 wage-earners	80, 522	2. 0
101 to 500 wage-earners	365, 119	9. 0
501 and over	3, 251, 525	80. 4
Total	4, 044, 293	100. 0

[23] The total figure does not include 117,641 wage-earners employed in industries for which comparable size groupings are not available. In order to include every possible industry in the group of the smallest plants, 1 to 50 wage earners, selections were made from the extremely narrow component groups—1 to 5, 6 to 20, and 21 to 50 wage-earners. The resultant inclusion of certain industries (e. g., radio, radio tubes and phonographs) in the 1 to 50 group, due to the smallness of the component segments and the consequent greater possibility of unusual situations applying thereto, still did not result in any noticeably large figure for the 1 to 50 wage-earner group. For the complete tabulation, see appendix I.

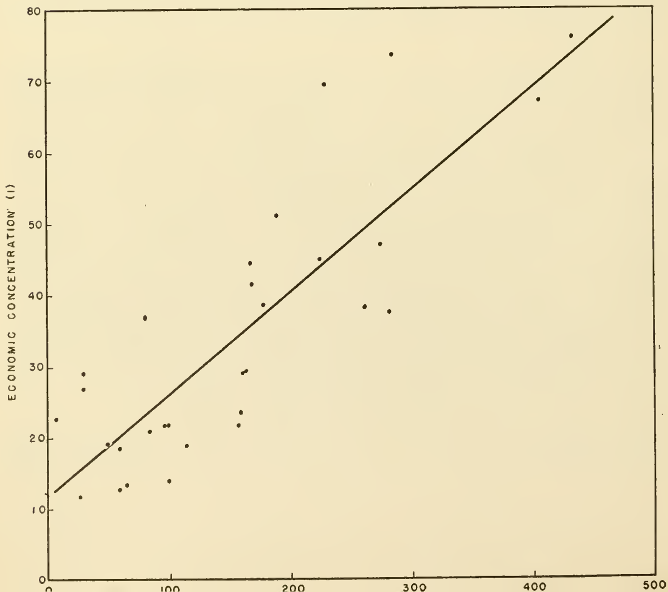
If the amount of electric energy used per man-hour indicates roughly the degree of utilization of modern technological equipment in producing plants, a correlation within given industries of the percentage difference (power differential) in electrical energy used per man-hour between large and small plants with the degree of economic concentration would indicate whether or not the extensive use of modern technological processes is related to the concentration of economic power. Such a correlation is shown graphically for 30 diversified manufacturing industries in chart XVI (table 27).

CHART XVI

THE RELATIONSHIP BETWEEN

ECONOMIC CONCENTRATION and POWER DIFFERENTIAL

Thirty Manufacturing Industries



The methodology involved in correlating the power differential between large and small plants with the degree of economic concentration in specific industries is summarized in appendix J. The coefficient of correlation is 0.83.[24] Considering the number of variables involved in each of the factors, the relationship between the two is comparatively high.

TABLE 27.—*Relationship between economic concentration and power differential (large plants over small plants)*

30 MANUFACTURING INDUSTRIES

Industry	Economic concentration [1]	Power differential [2]
	Percent	*Percent*
Aluminum products	76.0	432.0
Soap	73.5	283.6
Motor vehicle bodies and parts	69.4	227.9
Cereal preparations	67.0	404.2
Distilled liquors	51.0	188.9
Wrought pipe, welded and heavy riveted	47.0	274.2
Glass	44.9	223.6
Electrical machinery apparatus and supplies	44.4	167.4
Smelting and refining, nonferrous metal other than gold, silver, and platinum	41.5	168.4
Cigars	38.5	176.9
Petroleum refining	38.2	260.7
Cast-iron pipe and fittings	37.6	281.7
Steel barrels, kegs, and drums	37.0	80.9
Cement	29.2	29.6
Flour and other grain mill products	29.1	162.8
Engines, turbines, water wheels, and wind mills	28.9	160.9
Radios, radio tubes, and phonographs	27.0	29.1
Drugs and medicines	23.4	157.9
Pulp (wood and other fiber)	22.7	6.5
Feeds, prepared, for animals and fowls	21.7	96.0
Wirework	21.7	97.5
Lime	21.6	156.3
Machine tool accessories, etc	20.9	83.3
Clay products, other than pottery	19.2	50.0
Pottery, including porcelain ware	18.7	114.8
Rubber goods, other than tires, tubes, and boots and shoes	18.5	59.1
Paper	13.8	99.7
Machine tools	13.3	64.0
Insecticides and fungicides, etc	12.7	59.1
Malt liquors	11.8	27.2

[1] Percent of industry's value of products produced by its 4 largest concerns, 1935.
[2] Percent difference between large plants and small plants in use of electric energy per man-hour, 1937.

Source: Economic concentration, National Resources Committee, The Structure of the American Economy, pt. I, 1939, appendix 7, table I, pp. 240–249. Power differential, computed from U. S. Bureau of the Census, Census of Manufactures: 1937, Man-Hour Statistics for 105 Selected Industries, table 3, pp. 11–75.

The tendency for an increase in the power differential (or advantage) of large plants over small plants to be accompanied by an increase in the degree of economic concentration could mean that (1) the relationship is due merely to chance, or (2) an increase in concentration has resulted in an increase in the power differential, or (3) an increase in the power differential has resulted in an increase in concentration.

The first possibility may be eliminated because in certain industries a relationship between the relative efficiency of large over small plants and the degree of economic concentration is known to exist. The second implies that once a high degree of economic concentration in some way has been established, the power differential would be raised. But granting that this might have occurred, the power differential,

[24] The standard error: 10.0833 percent; the line of regression: $Y_c = 12.0243 + 0.1426134x$.

thus raised, would increase the advantage of the large plants and make possible the maintenance of the high degree of concentration established.

Regardless of whether the establishment of a high degree of concentration has increased the power differential or whether an increase in the power differential has resulted in greater concentration, it is evident that a primary causal factor of concentration is the existence of an advantage in operating efficiency of large plants over small plants.

CONCENTRATION AND INDUSTRIAL RESEARCH

THE GROWTH OF INDUSTRIAL RESEARCH

Technological development depends on continual invention, and invention today stems increasingly from large industrial research organizations. This is a consequence of the widening of the body of industrial knowledge, which has made it impossible for any one man, or even any small group of men, to master the innumerable technical details in each of the scientific fields involved in the inventive effort.

Groups of specialists working in large industrial laboratories, owned by vast corporate organizations, are replacing the individual isolated inventor. As Dr. Charles F. Kettering, vice president in charge of research, General Motors Corporation, has said, we are passing through "the transition period from the individual as an inventor to the group as an inventor * * * group invention rather than individual invention." [25] This transition is another manifestation of a basic technological process—the specialization of function.

Industrial research on an organized group basis has come to occupy a position of real importance in the economy aside from the technological advances which have emanated from it. "Measured in terms of employment, the 'research industry' is equal in importance to the dyeing and finishing of cotton fabrics which in 1937 ranked among the 45 manufacturing industries which provided the largest number of jobs." [26]

Here, the significance of industrial research is its relation to the concentration of economic power. If industrial research were to accelerate the process of concentration, then technology in a second way would impart an impetus to the concentration of economic power.

Industrial research has grown extraordinarily during the past two decades. Between 1921 and 1938 research personnel in this field rose by approximately 300 percent.[27] Another indication of the growth of industrial research is the decrease in the number of research workers employed on a part-time basis. In 1927 approximately 25 percent of the research personnel reportedly worked on a part-time basis; by 1938 the proportion had fallen to 3 percent.[28]

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[25] Hearings before the Temporary National Economic Committee, Part 30, p. 16293.

[26] Work Projects Administration, National Research Project, Industrial Research and Changing Technology, by George Perazich and P. M. Field, 1940, p. 40.

[27] Ibid., p. 7. In gathering the primary data for this survey the National Research Council stated that it "is not intended to list laboratories which are concerned merely with routine testing of raw materials and products, but it is desired to include all those which definitely devote some time to research looking toward the improvement and development of products." (Ibid., p. 2.)

[28] Ibid., p. 6.

The increase in research personnel in 22 industrial groups during this period is shown in table 28. With but 6 exceptions research personnel has grown by more than 100 percent; in the radio apparatus and phonographs and petroleum products industries the increase has been almost phenomenal in this 11-year period.

INDUSTRIAL RESEARCH AND THE COMPETITIVE SYSTEM

To determine whether or not increased industrial research has accelerated the concentration of economic power, it is necessary to analyze the role industrial research plays in the competitive system. Competition in a given industry may take three forms: (1) reductions in price, (2) improvements in quality, or (3) the addition of new features, parts, or gadgets to the product.

TABLE 28.—GROWTH OF RESEARCH PERSONNEL, FROM 1927 TO 1938, BY INDUSTRIAL GROUP

Industrial group:	*Percentage increase, 1927–38*
Chemicals and allied products	175.5
Petroleum and its products	538.7
Electrical communication	3.7
Electrical machinery, apparatus, and supplies	58.1
Consulting and testing laboratories	127.0
All other machinery	133.2
Rubber products	101.8
Motor vehicles, bodies, and parts	190.2
Agricultural implements (including tractors)	184.7
Miscellaneous	205.0
Iron and steel and their products, not including machinery	189.4
Food and kindred products	255.1
Stone, clay, and glass products	166.4
Nonferrous metals and their products	72.7
Radio apparatus and phonographs	1,600.0
Utilities (gas, light, and power)	89.4
Paper and allied products	177.5
Trade associations	96.9
Textiles and their products	252.9
Forest products	190.9
All other transportation equipment	17.0
Leather and its manufactures	151.6
Total	133.3

Source: Work Projects Administration, National Research Project, Industrial Research and Changing Technology, 1940, p. 19.

Industrial research plays an important, if not a dominant, role in each of these three forms of competition. For the producer engaged in intense price competition for whom reductions in cost are of primary importance, for the producer whose industry is characterized by a steady improvement in quality, and for the producer whose buyers have come to expect new features, the lack of a research organization to perform these functions might well be the cause of financial failure and disappearance from the industry.

Also industrial research may lead to concentration by drawing a large concern into the production of entirely new and different goods. Frequently a large company devises a completely new commodity or improves materially upon some relatively unused product through industrial research. Then because it has adequate financial resources

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and the technical equipment necessary to produce the article, the large concern comes to dominate a substantial proportion of the expanding market for the new commodity.[29]

In the process, costs may be reduced so that the price of the new item may be lowered and its market thus increased; quality may be improved; or new features may be added. But in each case, the achievement of these objectives is greatly facilitated by an industrial research organization. If large concerns have a marked advantage over small firms in the possession of industrial research organizations, the chances are considerably increased that the production of new commodities will be dominated by a few large companies.

The electric refrigerator industry is an interesting example of the way in which the production of a relatively new product has been dominated by a few large concerns, three of which were among the Nation's gigantic industrial enterprises long before their entry into the manufacture of electric refrigerators. In 1935 the percent of the industry's output of various sized domestic electric refrigerators produced by the industry's four largest concerns [presumably General Motors (Frigidaire), General Electric, Westinghouse, and Kelvinator-Nash (Kelvinator)] was as follows:

Capacity	Production of first 4 companies [1]	Percent of total
Under 6 cubic feet:		
Number	617, 037	70. 5
Value	$44, 115, 690	72. 4
6 to under 10 cubic feet:		
Number	348, 762	65. 0
Value	$36, 904, 509	66. 9
10 cubic feet and over:		
Number	11, 068	94. 7
Value	$2, 273, 002	93. 6

[1] Temporary National Economic Committee Monograph No. 27, The Structure of Industry, Part V, "The Concentration of Production in Manufacturing," appendix C.

While it is impossible to ascertain the exact role of industrial research in the establishment of this high degree of concentration, General Motors, General Electric, and Westinghouse are noted for the size of their research organizations. The three major objectives of industrial research—reductions in cost, improvements in quality, and development of new features—have been pursued vigorously by the research laboratories of these companies, and their constant attainment have been of primary importance in the expansion of the market for electric refrigerators.[30]

This example would indicate that the concern with an industrial research organization is at a definite advantage in the competitive conflict as well as in the development of new fields.

[29] In the annual report of E. I. du Pont de Nemours & Co. of 1937 it is found that products relatively unknown in 1929 accounted for approximately 40 percent of their total sales that year (Hearings before the Temporary National Economic Committee, Part 30, p. 16241).

[30] The General Motors Research Corporation, the General Electric Co., and the Westinghouse Electric & Manufacturing Co. are among the list of 45 companies reporting the largest research staffs in 1938. (See Work Projects Administration, National Research Project, Industrial Research and Changing Technology, p. 68.)

THE OWNERSHIP OF INDUSTRIAL RESEARCH

The possession of industrial research establishments is more characteristic of large firms than of small firms because of the complexity of organization and consequent expense of modern industrial research. For example, when he was before the Temporary National Economic Committee, Mr. Kettering described the way in which the research organization of General Motors is divided into several broad departments and these in turn are broken up into divisions according to fields of analysis. Thus there is a department of chemistry, within which are a fuel research division, a rubber research division, a plating research division, etc. There is a department of physics within which are an X-ray division, a high-voltage division, an ignition division, a spectroscope division, etc. There is a department of design within which are divisions of designing, of building, and of testing innovations. Then there are segments within the various divisions. For example, the department of chemistry has a materials division, of which a metallurgical unit is a component part.[31] Research pursued on such a scale is obviously costly. Mr. Kettering estimated that the total engineering and research budgets of the General Motors Corporation would amount to approximately ten or twelve million dollars a year.

In elaboration of this point, the National Research Project observes:

> In order that the full advantages of large-scale research may be realized, large capital outlays are required both for equipping the laboratory and for its operating expenses. When it is considered that a laboratory of 20 employees (including scientists and their assistants) requires perhaps $75,000 annually for operating expenses alone, it is evident that only corporations with large capital assets would be able to maintain a laboratory of this relatively modest size. If it is assumed that 1 percent of the total volume of sales is allocated to research a concern with a research budget of $75,000 would have to produce each year goods or services valued at $7,500,000. Some of the largest laboratories, in which the advantages of systematically organized research are most fully realized, have annual budgets of several million dollars. In some industries, moreover, certain research projects may continue for several years, involving correspondingly large expenditures, before the results become apparent, and in many cases no fruitful results are obtained.[32]

Industrial research is highly concentrated; there is probably no other basic function of general economic activity so dominated by a few enormous concerns. The National Research Project found that "13 companies with the largest research staffs, representing less than 1 percent of all companies reporting in the National Research Council survey, employed in 1938 one-third of all research workers, or as many as the 1,583 companies with the smallest research staffs." Half of the country's industrial laboratory personnel was employed by only 45 large research laboratories, "all but 9 of which are owned or controlled by companies which are among the Nation's 200 leading nonfinancial corporations."[33]

In individual industry groups the concentration was just as pronounced. In 1938 that quarter of the companies having the largest research staffs employed 59.3 percent of all research workers in blast

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[31] Hearings before the Temporary National Economic Committee, Part 30, p. 16294.
[32] Work Projects Administration, National Research Project, Industrial Research and Changing Technology, p. 45.
[33] Ibid., pp. 9–11.

furnaces, steel works, and rolling mills; 82.2 percent of all research workers employed in electrical machinery, apparatus and supplies; 88.3 percent in industrial chemicals; 89.0 percent in motor vehicles, bodies and parts; 85.0 percent in petroleum; 82.8 percent in radio apparatus and phonographs; 90.0 percent in rubber products; 56.9 percent in textiles and their products; and 78.5 percent in utilities (gas, light, and power).[34]

Perhaps the most important aspect of this concentration of industrial research is that—

> By and large, the mass of specialized data assembled in the course of industrial research does not become available to anyone except the owners of the laboratory. Although a few large concerns which carry on extensive studies in fundamental sciences frequently publish the results of their experiments, this is not typical of industrial research. The proportion of total findings published by concerns having industrial laboratories is only a fraction of the proportion published by academic and governmental laboratories. Even in cases where permission is given to individual scientists working in industrial laboratories to publish their experimental findings, the management usually reserves the right to examine such technical papers, modify their contents, and approve their publication only when it finds that this would not jeopardize its competitive position.[35]

Since industrial research is much more characteristic of large than of small concerns, and since it gives a competitive advantage to those firms able to pursue it, technology in this second way imparts impetus to the concentration of economic power.

CONCENTRATION AND PATENTS

Though technological advance does not depend upon patents, the granting of a monopoly by the State on a new product or process for a given period of time has been closely associated with this advance during recent times. There is no evidence that patents are a necessary inducement to technological development, for all during the industrial revolution, when widesweeping and fundamental technological changes took place, patent controls were of only limited importance. As a matter of fact, from 1793 to 1836 there existed in the United States only a registration system by which anyone who swore to the originality of his invention and paid the stipulated fee could secure a patent, the validity of which might later be determined by the courts. Not until 1836 were the fundamental features of our present patent system, particularly the policy of examining applications, established as part of the law of the land.

Patents today are granted in the United States on a machine, a product of manufacture or composition of matter, an art or process of making it, upon the appearance or ornamental character of an article, and on plants that are asexually reproduced. Scientific principles, scientific discoveries *per se* or the laws of nature cannot be patented.

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[34] Ibid., p. 10. It may be significant that in the least concentrated of these industry groups—textiles and their products—that quarter of the companies having the largest research staffs employed a smaller percentage of the group's total number of research workers than was the case for any of the other industrial groups; on the other hand, in the 2 most highly concentrated groups—rubber products and motor vehicles, bodies and parts—that quarter of the companies having the largest research staffs employed higher percentages of the total number of research workers than in any of the other industrial groups.

[35] Ibid., p. 47, footnote 13. One of the primary reasons for this protection of findings is the fact that they may be patentable, a consideration to be discussed more fully in the following section.

Patents extend for 17 years from the date of granting, except in the case of design patents which run 3½, 7, or 14 years, as the inventor elects. The sole right to use "a machine, a product of manufacture or composition, an art or process of making it," for an extended period of time obviously entails excellent potentialities for the centralizing of economic power.

TECHNIQUES OF CONTROL THROUGH PATENTS

Patents have been used in a wide variety of ways to establish a high degree of concentration of economic power over an industry. But the power exerted is frequently far greater than might be inferred from the existence of a 17-year legal monopoly.

There are two principal reasons for this: (1) Control may be extended well beyond the termination of the basic patent by means of so-called improvement or indirect patents. The operation of the basic equipment without these patented improvements is often impracticable, and thus control may be extended additional years for each improvement patent. (2) The life of a patent affords the company controlling it a considerable amount of time in which to become entrenched in a position of dominant economic power. During this period its monopoly income may enable it to engage in activities to secure the field to itself after the patent control is legally ended. The company may purchase potential rivals outright or buy their patents; it may contract for the services of the leading inventive talent in the field; it may bring expensive lawsuits upon so-called infringers, the expense of which in most instances can much more readily be borne by the established firm than by the accused companies; it may pursue policies of predatory price cutting, designed to force out of business those firms with less financial staying-power. In short, it may accumulate during the period of its patent control such financial strength that it can vigorously pursue any of the numerous policies designed to control the extent of competitors' operations, or to force competitors completely out of business.

It would be impossible in this brief survey to describe all of the numerous ways in which patents have been used to establish economic concentration. Several specific cases, illustrative of particular techniques of effecting economic control through patents, will be briefly analyzed.

A partial list of these techniques includes the use of patents to establish command over the production of a given commodity (1) by compelling members of an industry to lease patented equipment; (2) by dividing territory and allocating geographic markets among several producers; (3) by determining the type and amount of goods to be produced with patented equipment; and (4) by forcing licensees of a given commodity to follow the pricing and marketing policies of patent-holding producers in an industry.

The United Shoe Machinery Co. is a frequently cited example of control exerted over an industry by means of patents. This company was founded during the great era of consolidations in 1899, and was an amalgamation of seven concerns. It acquired all the assets of these firms, including the vital patents of the Consolidated & McKay Lasting Machine Co. on lasting machines, and the Goodyear Shoe

Machinery Co. patents on welt-sewing and outsole-stitching machines. It subsequently acquired the shoe machinery business and assets, including patents, of 57 individuals, partnerships, and corporations.

But the acquisition of concerns engaged in the manufacture of shoe machinery was not considered sufficient to obtain complete patent control over the industry because innovations were constantly being made by professional inventors in the field and by the United Co.'s own employees. Therefore, it contracted with 95 percent of the inventors of shoe machinery for all their inventive efforts and caused its employees to assign to the company all inventions relating to shoe machinery which they might devise while in the service of the company. The control of these two principal sources of invention in the field has been extremely valuable to the United in maintaining its practically complete monopoly on shoe machinery patents.

In its arrangements with shoe manufacturers, the United Shoe Machinery Co. has leased rather than sold its equipment, thereby retaining title to the machines and the power to withdraw them whenever it believed its patent rights were infringed. Furthermore, it has leased its machines subject to provisions which forced the shoe manufacturer to obtain either all or none of the shoe machinery needed in his factory from the company.

In order to compete effectively with the United, would-be rivals had to develop a new and complete line of shoe machinery. This was attempted by Thomas J. Plant who developed a complete line of shoe machines for manufacturing welt, turn, and McKay shoes, with which he equipped a factory in 1910. Confronted with this competition, the United proceeded to acquire the Plant assets, most important of which were the Plant patents—206 granted by the United States and 259 by various foreign lands.

Consequently, the United Shoe Machinery Co. came to control more than 95 percent of the entire shoe machinery business in the United States and to constitute the only firm which produces a full line of shoe machinery.[36]

In 1940 the corporation owned and controlled patents and inventions covering more than 300 types of shoe machinery—the leasing of which constituted the larger proportion of the company's net income.[37]

The General Electric Co. for many years has been the largest organization in the world engaged in the development of apparatus and equipment for generating and transmitting electrical power, and the manufacture of electrical appliances. It produces approximately 20 percent of all electrical equipment sold in the United States, or about twice the amount made by its largest domestic competitor, the Westinghouse Electric & Manufacturing Co.[38]

In specific items, its dominance is much greater. This is particularly true of the manufacture of electric lamp bulbs (i. e., large type bulbs for general household and commercial uses). As recently as 1917 bulbs were manufactured largely by manual processes, and at that time there were five manufacturers of bulbs in the country. By 1939 the process of manufacture was almost entirely mechanized, and the number of

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[36] Floyd L. Vaughan, Economics of Our Patent System, Macmillan, New York, 1925, pp. 79–85.

[37] Standard Statistics Co., Inc., Standard Individual Corporation Descriptions, 1940, "United Shoe Machinery Company."

[38] Ibid., "General Electric Co."

producers reduced to two—General Electric and Westinghouse. This increase in concentration developed as the most economical production is possible only in highly mechanized plants of very large capacity and because control over production is exercised by the owners of patents.

The General Electric Co. is one of the two owners of such patents and produces both glass bulbs and the finished lamps. The Corning Glass Works owns the patents on the glass bulbs *per se* and supplies bulbs to all other American electric-lamp manufacturers except General Electric.

The absence of competition in the manufacture and sale of bulbs is due principally to the control over patents exercised by these two firms. Together they own or control not only all of the product patents, that is, those relating to bulbs, tubing, etc., but also the patents on the machinery involved in the manufacture of bulbs.

Their control of the equipment essential to the manufacturing process gives these concerns absolute dominance over the industry, regardless of the patents they hold on finished products. But this control of the equipment through patents has not brought the two firms into conflict. They have entered into cross-licensing agreements. The present agreements, setting forth terms and provisions under which licenses are granted to others, have been extended to 1951.

Competition, in the face of this patent control could arise only from infringements by domestic producers or from foreign sources of supply. But the General Electric Co. has usually succeeded by means of lawsuits in making it legally impossible and financially ruinous for any concern to pursue an extended policy of violating General Electric patents.

The possibility of foreign competition is rendered remote by the existence of agreements between the leading foreign producers, members of the international cartel, and a subsidiary of General Electric, the International General Electric Co. In fact, definite international agreements exist concerning the manufacture and sale of bulbs in the principal world markets. In addition, the International General Electric Co. owns stock in a number of foreign concerns engaged in the industry.[39]

One of the most interesting examples of the extent to which control of technological improvements through patents has been used to establish a high degree of concentration is the glass container industry. This industry is dominated by two major companies which have established almost complete control over the production of glass containers. These two firms are the Hartford-Empire and the Owens-Illinois Glass Cos., of which the former is merely a patent-holding and research organization. Owens-Illinois is the largest glass container manufacturing company in the country.

In 1937 approximately 29.2 percent of all glass containers were made on Owens machines while 67.4 percent were made on Hartford machines.[40] Since Owens-Illinois has not licensed a newcomer in the industry since 1914, Hartford-controlled machines are practically the only equipment glass-making producers can operate unless they use obsolete, competitively inadequate machines on which patents have

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[39] U. S. Tariff Commission, Incandescent Electric Lamps, Report No. 133, Second Series 1939.

[40] Hearings before the Temporary National Economic Committee, Part 2, Patents, p. 383.

expired, or machines of foreign make whose patent status in this country has not yet been established.

The licenses granted by the Hartford-Empire Co. not only reserve ownership of the machine to the parent company, but in some cases also prescribe the type of commodity to be produced with the equipment, the quantity of production allowed, and the geographic areas in which the goods may be sold.[41]

These two companies have, in effect, allocated the milk bottle field to the Owens-Illinois, Thatcher and Liberty Glass Cos., which, in 1937, made 75 percent of the milk bottles produced. Fruit jars for domestic use have been allocated to Ball Brothers Co., which, in 1937, produced 76 percent of the country's fruit jar output. Numerous similar provisions govern the production of practically every variety of glass container.

Since the companies allocate quotas of production they exercise an effective control over prices in the various divisions of the industry. Quotas apply to every producer of glass containers except Owens-Illinois and Hazel Atlas. Competition within geographical areas is limited through the companies' power to allow the sale of containers only in specified areas. These controls are effected by the power to withdraw or refuse licenses.

Any action which could be construed by Hartford-Empire as an infringement upon its patents almost inevitably results in litigation. Hartford-Empire has engaged in expensive, long drawn-out law suits, which are extremely bothersome even to the large manufacturers of glass containers, and are often ruinous to the small companies.

The technique of extending control over the industry after the expiration of basic patents has been carefully exploited by Hartford-Empire. One of the methods is the use of improvement patents which are taken out to protect an improvement on a machine; another is the use of so-called indirect patents. During 1927–29 Hartford applied for 200 patents, 112 of which were indirect or blocking patents.[42]

Another means of restricting competition by the use of patent controls is the refusal on the part of Hartford-Empire to license new capital, thus in effect freezing the economic structure of the industry.

Hartford-Empire does not attempt to stipulate in its written contracts the prices at which glass containers are to be sold, but it does engage in activities designed to prevent price-cutting and to insure "fair" prices to its licensees. Complaints from its licensees that certain other producers are indulging in price-cutting are usually dealt with promptly by Hartford-Empire. In some cases it has even forced out of business certain concerns which were departing from the accepted price policies of the industry.

As a result of this control, prices are uniform throughout most of the industry. When changes do occur they are initiated by recognized price leaders in the respective fields. Thatcher sets the price on milk bottles; Ball Bros. on domestic fruit jars; Hazel-Atlas on wide-mouth ware (largely packers' ware); while Owens-Illinois leads

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[41] Ibid., pp. 396–433.
[42] Ibid., Exhibit No. 125, p. 779.

on narrow-mouth ware (including proprietary and prescription ware and beverage bottles).

This industry thus illustrates the way in which technological improvements protected by patents have been the means not only of securing a high degree of economic concentration but also the control of prices and marketing policies.[43]

CORPORATE SIZE AND EARNING POWER

The advantages technology imparts to large-scale operation indicate that an increase in size of operation would logically be accompanied by an increase in earning power. In fact, such a relationship has been found to exist.

In a study of corporate earnings related to corporate size during 1931–36, Professor William L. Crum of Harvard University found it

> strongly indicated though not fully established that, in all branches of industry large enough to show wide size distribution, (1) rate of return increases with size unmistakably in the low and moderately large size classes; (2) the advance in rate may continue in all size classes, or may disappear or even be replaced by a moderate reduction in the high size classes; (3) even in cases for which rate declines in the highest size classes, rates for those classes remain emphatically above those for the lowest class.

It is further to be noted that "these conclusions appear valid in separate years, in any stage of the business cycle."[44]

In arriving at the rate of return, Professor Crum divided residual earnings—profits, as defined by the Treasury—by the owners' stake in enterprise—the book value of the equity, and used total assets, as reported on the balance sheets accompanying the corporation tax returns, as his criterion of size.

Although such a computation admits of only general trends, the remarkable smoothness of the curves, and their close conformity to a basic pattern led Dr. Crum to conclude that "The larger the corporation, the higher is the rate of return, on the average; and this relation holds, with surprising constancy, in each of the six years 1931–36."[45]

The trend of corporate earnings in relation to the size of corporations is shown on chart XVII, table 29, for all divisions and for specific fields most likely to be affected by technology—manufacturing, mining, public utilities, and construction.

It is impossible to ascertain the exact extent to which technology is responsible for this phenomenon. Since it was found by Professor Crum that this relationship between corporate earnings and size could not be accounted for by such non-technological factors as the degree of indebtedness of corporations of each size, or by profits arising from price fluctuations affecting inventory, or, to any considerable extent, by the compensation of principal executives, and since the data already presented in this study indicate generally that technological factors—efficiency of operation, industrial research, and patent control—confer economic advantages on large-scale operation, it can be concluded that technology is undoubtedly responsible to an appreciable extent for

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[43] Ibid., pp. 547–548. The original legal basis of the patent system, the English Statute on Monopolies of 1623, contained a specific provision relating to prices; it permitted the granting of fourteen-year monopolies, provided that "they be not contrary to law nor mischievous to the state, by raising prices of commodities at home, or hurt of trade, or generally inconvenient."

[44] William L. Crum, Corporate Size and Earning Power; Harvard University Press, Cambridge, 1939, p. 230.

[45] Ibid., p. 32.

the rise in corporate earnings which accompanies increasing corporate size.

CHART XVII

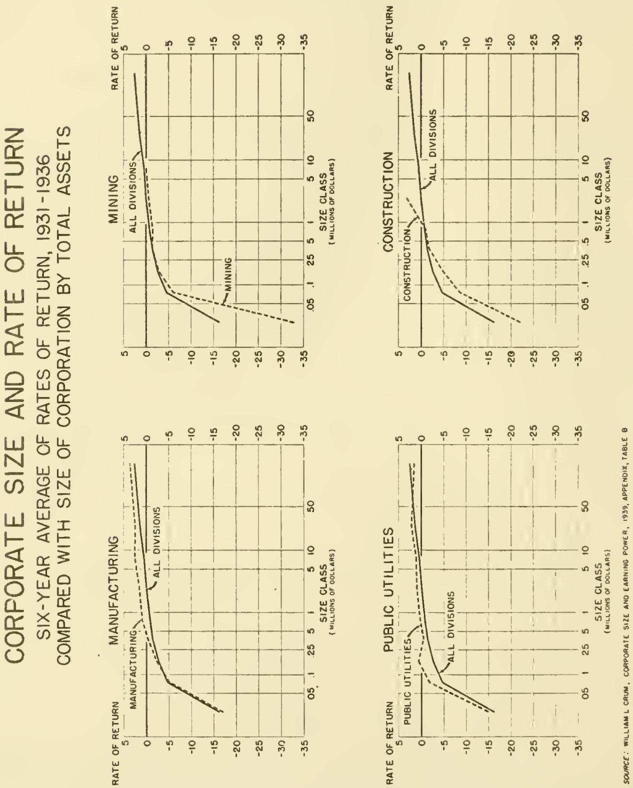

TABLE 29.—*Corporate size and rate of return, 6-year average of rates of return, 1931–36, compared with size of corporation by total assets*

Size class (millions of dollars)	All divisions	Mining	Manufacturing	Construction	Public utilities
0	−16.34	−33.01	−17.24	−22.14	−15.07
0.05	−4.73	−6.24	−5.22	−8.74	−1.85
0.10	−2.68	−2.95	−2.36	−4.92	.60
0.25	−1.40	−1.38	−.33	−1.79	−.51
0.50	−.80	−1.52	.80	−1.17	.15
1	−.05	−.57	1.56	3.26	1.00
5	.38	−.05	2.54	----------	1.14
10	1.44	----------	2.47	----------	2.22
50	2.59	----------	3.58	----------	1.52

Source: William L. Crum, Corporate Size and Earning Power, Harvard University Press, 1939, appendix, table B.

CONCLUSION

In this study the labor-displacing effects of technology were weighed against the compensatory forces presumably inherent in our economic system. However, there exists no measure by which the balance between the labor-saving effects and the compensatory forces can be quantitatively determined. If such a measure were available, it would still be exceedingly difficult to allocate to each compensatory force its share of responsibility.

Certain indirect methods can be used to determine whether balance exists. For example, the existence of a large amount of long-term unemployment would indicate lack of balance.

For over a decade this condition has been an all too conspicuous characteristic of our economy. At the beginning of 1940, for example, the estimates of the total amount of unemployment ranged from 8,500,000 (by the National Industrial Conference Board) to nearly 12,000,000 (by the Congress of Industrial Organizations).[46]

If it is assumed that under normal conditions the present economic system would provide full employment, then the very existence of large-scale unemployment denotes a state of unbalance. The question of greatest importance is whether this unbalance may be expected to continue.

It seems apparent that technology will continue to increase labor productivity, to displace skilled occupations, and to reduce unit labor costs. In the absence of effective offsetting forces, economic and social distress may be expected to accumulate.

Any reduction of hours corresponding with the declines that took place during the World War and immediately after the enactment of the National Industrial Recovery Act must be regarded as distinctly remote because of legislation establishing the 40-hour week and a widespread acceptance of it as the norm of employment.

The development of great, new industries likewise holds slight promise of creating sufficient employment to offset the labor-displacing effects of technology, especially since the eight general fields examined seem unlikely to create much employment. The limitations on the new industry stimulus involved in the substitution of products requiring less labor for those employing more labor per unit, the capital-saving characteristics of modern technology, and the pattern of present income distribution make it impossible to rely heavily upon their development as an immediate compensatory force.

The third force which might offset labor-displacement is the reduction of prices. In economic theory, price reductions are regarded as a primary stimulus to the expansion of economic activity. However, concentrated industries tend to make relatively little use of this technique to expand output. If concentration continues to characterize a large segment of the economy, there is little basis for assuming that extensive use will be made of price reductions in the future. Actually it appears probable that much of the economy will con-

[46] For a discussion of prevailing estimates of unemployment, see Harvard University, Review of Economic Statistics, "Estimates of Unemployment in the United States," by R. A. Nixon and P. A. Samuels, August 1940. This analysis concludes, "With recognized qualifications, however, the series compiled by the organizations here studied (the Alexander Hamilton Institute, the American Federation of Labor, The Congress of Industrial Organizations, the National Industrial Conference Board, and the President's Committee on Economic Security—Robert R. Nathan, consultant) provide fairly reliable indications of the volume of unemployment in the United States."

tinue to be marked by concentration, since technology through the greater efficiency of large-scale operation, through industrial research and through patents, contributes materially to the growth of concentration. Thus there is presented this fundamental contradiction: *while technology on the one hand creates tremendous economic problems through the displacement of labor, on the other it induces concentration, thereby impeding the operation of the compensatory force of price reductions.*

Higher wages are regarded by some as a possible stimulus. But in analyzing the trend of unit labor costs, it was found that even during periods of the greatest increase in wages, the advances in average hourly earnings were generally exceeded by still greater increases in output per man-hour, with the result that unit labor costs decline. This tendency for increases in labor productivity to exceed those in wages limits greatly the possibility of a material stimulus emanating from this source.

From where else can the stimulus be expected to come? From war? If the preparation for and the conduct of war constitute the only adequate compensatory force to the labor-displacing effects of technology, the proposition would then be established that only through war can the present economic system be operated in such a way as to approximate full employment.

Today a state of unbalance exists, and it seems likely that under present conditions unbalance will continue and perhaps become even more pronounced.

APPENDIX A

MEASURES OF LABOR PRODUCTIVITY[1]

(1) One of the first methods introduced to indicate the use of machinery, and by inference the productivity of labor, was the measurement of the amount of horsepower utilized or the rated horsepower capacity of power equipment. Statistics on horsepower, as a measurement of labor productivity, are deficient in two respects: (*a*) They do not give a perfect record of the changes in power used or even of installed power equipment; (*b*) the changes in power per worker, even if precisely measured, do not represent adequately the changes in productivity because some important mechanical improvements actually decrease rather than increase power requirements.

Use of power by no means corresponds with the rated capacity of power equipment. The possibility of running motors with an overload, together with improvements in transmission, tends to lower the capacity without changing the amount of work that can be accomplished. When electric motors are driven by current generated in the plant, their rated capacity is likely to exceed considerably the rated capacity of the prime movers because all motors in an establishment do not run at the same time or at full capacity; consequently, the rated capacity may be increased without a corresponding change in work done.

A somewhat better measure of labor productivity is the amount of power actually used. It is inadequate because certain labor-saving techniques decrease the amount of power used. Furthermore, industries which use heavy raw materials not easily handled require a relatively large amount of power; but their large consumption of power by no means indicates that labor productivity is higher than in industries which use lighter and more tractable materials.

(2) The machine-output measure is the ratio of output prepared by machine methods to hand methods in specific phases of productive operations. The chief problem in the use of this measure is the difficulty of obtaining data which would clearly differentiate between the proportion of total output produced by machine methods and that produced by hand methods. The border line cases between hand processes and machine processes would necessitate arbitrary determinations as to whether an operation in which a worker utilizes a simple machine tool is a machine or a hand method. Furthermore, except for special studies in fields such as the cigar, glass bottle, pig iron, and bituminous coal industries, there are no primary data from which such a computation could be made.

(3) The machine-labor ratio is somewhat similar to the machine-output ratio except that it represents the proportion of machine workers to the total labor force instead of the proportion of machine-made goods to the total physical output. The difficulty of classification, however, remains the same. If an arbitrary classification of all

[1] The first 4 are adapted from Harry Jerome, Mechanization in Industry, National Bureau of Economic Research, New York, 1934, pp. 205–254.

workers is made according to their connection with machine processes, it would still be defective as a measure of labor productivity. In two industries with exactly the same proportion of machine workers to hand workers, labor productivity might be much higher in one than in the other due to the use of more productive equipment.

(4) The labor-expense measure is the ratio of wages to value added by manufacture. Its great advantage is that it can be regularly computed for particular industries from data gathered by the Census of Manufactures. Wages as a percent of value added indicates the amount in actual dollars labor receives for productive effort in proportion to the total value of product less the cost of materials, supplies, containers, fuel, purchased electric energy, and contract work.

This ratio fluctuates, however, not only because of changes in labor productivity, but also because of price fluctuations in both finished products and raw materials. To the extent that prices are constant, variations in the ratio of wages to value added would indicate the trend of labor productivity. Until price indexes, designed for this purpose, which make possible the accurate adjustment for price changes have been compiled, the ratio will possess more usefulness in indicating changes of labor's share in the creation of dollar values rather than changes in labor productivity.

(5) Physical output per wage-earner is a more widely used measure of changes in labor productivity. If changes in output of individual workers over an extended period of time are to be measured, production per wage-earner probably constitutes the best available measurement. Labor productivity is usually considered, however, in terms of the total amount of labor required rather than the total amount of goods produced by any individual worker in a given period. Changes in weekly hours may considerably distort output per wage-earner as a measure of labor productivity. The amount of labor required over a period of time to produce a given unit of goods may decrease, while the amount of goods produced by an individual wage-earner may actually decline due to a decrease in weekly hours.

(6) Output per man-hour indicates most accurately the amount of labor required to produce a given unit of goods. Reductions in weekly hours, changes of price, or any of the factors which tend to distort the other measures of labor productivity do not affect output per man-hour.

While it is undoubtedly the best available measure of labor productivity, two limitations deserve attention. The reduction of all labor to a least common denominator, man-hours, removes the possibility of noting changes in types of work. Therefore, while man-hour output reflects accurately the amount of labor time required to produce a given unit of goods, it does not indicate changes in the quality of labor required. If changes in the quality of labor such as the replacement of skilled by unskilled workers are considered occupational rather than productivity phenomena, this objection to the use of man-hour output is automatically eliminated.

Output per man-hour also fails to reflect substitutions of materials which may reduce the amount of labor required for a given function. The actual loss to labor from this source could be measured by man-hour indexes but since they are related to units of specified types of goods, they do not reveal, as now computed, those changes in labor productivity resulting from replacements of materials.

APPENDIX B

PRODUCTION AND MAN-HOUR INDEXES

The index of production used for manufacturing is that computed by the National Bureau of Economic Research and extends to 1937. It is based upon all manufacturing industries reporting to the Census of Manufactures. In computing this index, the National Bureau of Economic Research obtains physical production series on all items for which such data are compiled by the Census; and on those items for which such data are not available it derives indexes showing the probable trend of output by means of ratios based on such measures as value added by manufacture and employment. To indicate the trend of physical production for 1938 and 1939 the Federal Reserve Board index of manufacturing production was linked to the National Bureau series.[1]

The indexes of production for anthracite and bituminous coal mining are derived from tonnage figures. Because they fail to take account of cleaning, sorting, and adaptation to specialized means, the rise in man-hour output during recent years is minimized. With declining production, the elimination of high cost mines, especially in anthracite mining, tends to raise man-hour output.

In steam railroads [2] the production index used is derived from revenue traffic units on the generally used basis of revenue passenger-miles times 2.6 plus revenue ton-miles.

Man-hour output for each of the fields has been computed by Witt Bowden of the United States Bureau of Labor Statistics from data gathered by that agency.[3]

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[1] The production index of the National Bureau of Economic Research is not yet published but was supplied by Mr. Solomon Fabricant. This index is described in a forthcoming volume by Mr. Fabricant to be published by the National Bureau and entitled "The Output of Manufacturing Industries, 1899–1937."

[2] Reference in this report to steam railroads is to class I steam railroads, which in 1938 handled 99.39 percent of all freight traffic based on ton miles or 94.38 percent based on tons of freight carried, and 99.87 percent of all passenger traffic based on passenger miles or 99.61 percent based on number of passengers carried.

[3] The indexes of man-hours, excluding the break-down for bituminous coal and anthracite mining, are published for certain years in an article by Dr. Bowden in the Monthly Labor Review, September 1940, "Wages, Hours, and Productivity of Industrial Labor, 1909–39."

APPENDIX C

THE NATIONAL RESEARCH PROJECT INDEXES OF LABOR PRODUCTIVITY IN MANUFACTURING INDUSTRIES

The National Research Project, in the construction of the index numbers designed specifically to measure the trends of employment opportunities, developed formulas which necessitate the weighting of constituent series by labor time rather than value. It is the purpose of these formulas to present an index of production which, when divided by the relatives of man-hours and multiplied by 100, yield the same index of productivity which could be obtained by averaging with appropriate weights the relatives of the output per man-hour for the several products comprising the index of production. Certain data requisite for the development of such formulas are not available. The principal problem in the formulation of these indexes was a frequent lack of comparability between figures on physical production and those on man-hours. To attain approximate comparability, the original data were at times subjected to considerable adjustment.

Since man-hour figures for individual products, required for weighting purposes, are almost completely non-existent, it was necessary to use unit-value weights or unit-value added weights for the purpose of combining industry indexes into group measures, and group indexes into over-all series. The method of computing man-hour figures for most of the industries consists in multiplying employment by average weekly hours.

Because the index of productivity can be obtained only as the quotient of a production index and an adjusted corresponding wage-earner or man-hour index, the validity of the productivity index depends entirely on the accuracy of the production and labor series. Concerning the validity of the indexes, the Central Statistical Board observes that—

> In view of the fact that innumerable adjustments had to be made to the available data to correct for the lack of uniformity as to scope, coverage, and detail, and that many of the indexes are based on estimates, it is difficult to determine the accuracy of these measurements. In general, it may be said that although the indexes may not register the correct magnitude of the year-to-year movements, they do probably indicate the direction of the trends accurately.[1]

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[1] Report of the executive secretary to the Central Statistical Board for August and September 1939, p. 2.

APPENDIX D

THE REDUCTION OF VARIETIES THROUGH STANDARDIZATION[1]

Some of the more obvious advantages gained from standardization follow. To the manufacturer: Less capital tied up in slow-moving stocks, simplified inspection requirements, longer runs with fewer changes, less idle equipment, less stock to handle, larger production units, less special machinery, more prompt delivery, less chance of error in shipment, and less obsolescence in material and equipment. To the jobber, wholesaler, and retailer: Increased turn-over, elimination of slow-moving stock, staple lines—easy to buy and quick to sell—greater concentration of sales efforts on fewer items, decreased capital invested in new stocks and repair parts, less storage space required, and decreased overhead and handling charges. To the consumer: Better values than otherwise possible, better service in delivery and repairs, and better quality of products.

Reduction of varieties effected by standardization

Item	Varieties		
	Before simplification	After simplification	Percent reduction
Abrasive products, coated	8,000	1,865	77
Asphalt	102	11	89
Axes, forged	845	384	54
Bags:			
Glassine ... sizes	124	26	79
Paper, grocers'	61	47	23
Paper, notion and millinery ... sizes	188	28	85
Barrels, steel; and drums ... capacities	66	26	61
Bars:			
Steel, reinforcing	32	11	66
Steel, spiral, reinforcing ... sizes	7	4	43
Beds, hospital { lengths	33	1	97
widths	34	1	97
heights	44	1	98
Blackboard, composition { colors	3	2	33
widths	18	3	83
lengths	90	5	94
Blankets	78	11	86
Board:			
Binders	718	10	99
Box, thicknesses of	244	96	61
Boilers:			
Range, and expansion tanks	130	13	90
Steel, horizontal firebox heating	2,328	38	98
Bolts, plow	1,500	840	44
Books, composition, counts (number of leaves)	76	41	46
Bottles, carbonated beverage:			
Soda and imported ginger ale { shapes	15	12	20
capacities	15	12	20
heights	78	6	92
weight of glass	16	8	50
Water and water shape ginger ale { capacities	11	3	73
heights	13	3	77
weight of glass	18	4	78
Beers, export, select, or C. S. { capacities	8	3	62
heights	18	2	89
weight of glass	18	2	89

[1] Source: National Bureau of Standards, Letter Circular LC 501, September 3, 1937.

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Reductions of varieties effected by standardization—Continued

Item	Varieties: Before simplification	Varieties: After simplification	Varieties: Percent reduction
Bottles, milk and cream, and bottle caps	49	4	92
Boxes:			
Corrugated and solid fiber, for canned fruits and vegetables	150	41	73
Corrugated, for department and specialty store use—sizes	322	75	77
Folding, for department and specialty store use—sizes	262	59	77
Folding, 1-pound for coffee	100	2	98
Set-up—sizes	1,084	194	82
Brick:			
Common; and rough and smooth-face brick	75	2	97
Face, rough and smooth; and common brick	75	2	97
Paving, vitrified	66	4	94
Sand-lime	45	1	98
Brushes:			
Calcimine, block sizes for—widths	47	10	79
Calcimine, block sizes for—thicknesses	34	8	76
Paint and varnish	480	143	70
Cans:			
Fruit and vegetable (names and dimensions)	200	21	90
Tinned, steel, ice cream—types and sizes	14	5	64
Caps, bottle, milk and cream; and milk and cream bottles	49	4	92
Cartons, ice cream; and ice cream brick molds—mold sizes	30	1	97
Cartridges, metallic	348	194	44
Chain, welded	1,831	1,214	34
Checks, guest, restaurant:			
Cardboard checks—grades	4	3	25
Cardboard checks—widths	12	5	58
Cardboard checks—lengths	16	14	12
Paper checks—grades	7	4	43
Paper checks—widths	10	8	20
Chinaware:			
Cafeteria and restaurant	700	309	56
Dining car	700	345	51
Hospital	700	345	51
Hotel	700	258	63
Cloth, screen, wire insect	360	154	57
Containers (cans):			
Fruit and vegetable (names and dimensions)	200	21	90
Tinned, steel, ice cream—types and sizes	14	5	64
Containers:			
Extracted honey—sizes	65	10	85
Glass; for cottage cheese and sour cream—do	20	3	85
Glass, for mayonnaise and kindred products—capacities	25	5	30
Glass, for preserves, jellies, and apple butter—preserve jars	40	9	77
Glass, for preserves, jellies, and apple butter—jelly glasses	25	7	72
Glass, for preserves, jellies, and apple butter—apple butter jars	6	4	33
Cups, ice cream; and cup caps—cups	16	5	69
Cups, ice cream; and cup caps—caps	15	6	60
Drums, steel; and barrels—capacities	66	26	61
Duck, cotton	460	94	80
Elbows and fittings for eaves trough and conductor pipe—varieties	110	76	31
Fencing, woven-wire; and woven-wire fence packages—styles	552	71	87
Fencing, woven-wire; and woven-wire fence packages—package sizes	2,072	200	90
Files and rasps	640	475	26
Fittings, wrought iron and wrought steel, and pipe and valves—pipe sizes	62	48	24
Flashlight cases, metal and fiber	25	7	72
Fungicides and insecticides—package sizes	38	22	42
Galvanized, ware, tinware, and japanned ware	1,154	873	24
Gauze, surgical	70	29	59
Goring, shoe, elastic—qualities	16	5	69
Goring, shoe, elastic—widths	13	9	31
Hammers, forged	386	180	53
Hatchets, forged	242	118	51
Insecticides and fungicides—package sizes	38	22	42
Investment, dental: plaster and artificial stone, packaging of—plaster	22	3	86
Investment, dental: plaster and artificial stone, packaging of—investment	26	13	50
Insulators, porcelain, 1-piece	272	210	23
Jacks, screw, bell-bottom—sizes	78	38	51
Japanned ware, tinware, and galvanized ware	1,154	873	24
Lath, metal (expanded and sheet)	125	29	76
Lights; sidewalk, floor, and roof—sizes	120	6	95
Lights; sidewalk, floor, and roof—styles	80	5	94
Lights; sidewalk, floor, and roof—shapes	10	2	80
Lining, brake, automobile	100	37	63
Lockers, steel	65	23	64
Lumber, rotary cut, for wire-bound boxes—lengths	102	6	41
Lumber, rotary cut, for wire-bound boxes—widths	65	6	91
Lumber, rotary cut, for wire-bound boxes—thicknesses	9	6	33

Reductions of varieties effected by standardization—Continued

Item		Varieties: Before simplification	After simplification	Percent reduction
Millboard, asbestos; and asbestos paper	paper	72	20	72
	millboard	21	4	81
Mirrors, dental cone-socket	sizes	7	4	43
Molds, brick, ice cream; and ice cream cartons	mold sizes	30	1	97
Nails, cut, small, and cut tacks	sizes	428	185	57
	packages	423	127	70
Packages, salt	packages	71	38	46
Packaging of dental plaster, investment, and artificial stone	plaster	22	3	86
	investment	26	13	50
Packaging of insecticides and fungicides		38	22	42
Packaging, woven-wire fence; and woven-wire fencing	styles	552	71	87
	pkg. sizes	2,072	200	90
Paper:				
Asbestos; and asbestos millboard	paper	72	20	72
	millboard	21	4	81
Photographic		73	62	15
Tissue	roll, sizes	13	3	77
	shoe, sizes	21	4	81
Pipe:				
Wrought-iron and wrought-steel; and valves and fittings	pipe sizes	62	48	24
Conductor; and eaves trough, elbows, and fittings	varieties	110	76	31
Plaster:				
Adhesive		26	15	42
Dental; investment, and artificial stone, packaging of	plaster	22	3	86
	investment	26	13	50
Rasps and files		640	475	26
Refractories, malleable foundry		188	25	87
Roofing, iron and steel		292	178	39
Rubber, dental, base and veneering	colors	42	11	74
Scoops, shovels, and spades (first revision)		5,136	1,161	77
Screen cloth, insect, wire		360	154	57
Shells, loaded paper shot		4,067	283	93
Shovels, spades, and scoops (first revision)		5,136	1,161	77
Slate:				
Blackboard		251	25	90
Roofing	possible sizes	1,260	309	75
Structural		827	118	81
Spades, shovels, and scoops (first revision)		5,136	1,161	77
Spirals, steel, reinforcing	sizes	7	4	43
Spools, metal, for annealing, handling, and shipping wire		8	6	25
Steel, sheet		1,630	209	87
Stone, artificial, dental; plaster and investment, packaging of	plaster	22	3	86
	investment	26	13	50
Sweeps, floor	block lengths	11	7	36
Tacks, cut, and small cut nails	sizes	428	185	57
	packages	423	127	70
Tags, shipping, paper	sizes	16	8	50
	grades of stock	21	8	62
	thicknesses	7	5	29
	colors	32	15	53
Tanks:				
Expansion, and range boilers		130	13	90
Storage, hot water	dimensions and capacities	120	14	88
Tape, sealing, paper, No. 1 kraft	weights of paper	8	3	62
Ternes, roofing		1,208	936	22
Textiles, cotton, hospital and institutional		454	26	94
Tile, building, hollow		36	22	39
Tinware, galvanized, and japanned ware		1,154	873	24
Tools, forged		665	503	24
Towels, terry, fast selvage	sizes	74	6	92
Traps, lavatory and sink, brass		1,114	76	93
Trough, eaves; and conductor pipe, elbows, and fittings	varieties	110	76	31
Turnbuckles	sizes	248	115	54
Twines, hard-fiber (ply and yard goods)		1,304	1,124	14
Units, building, concrete		45	18	60
Valves, wrought-iron and wrought-steel; and pipe and fittings	pipe sizes	62	48	24
Wheelbarrows		125	27	78
Wheels, brush, dental		50	10	80
Wheels, buffing, full disk	stock diameters	17	11	35
Wheels, grinding		715,200	254,400	64
Wheels, grinding, dental lathe		91	10	89

APPENDIX E

WAGES AS A PERCENT OF VALUE ADDED BY MANUFACTURE

The following table shows wages as a percent of value added by manufacture for 50 representative industries in 1935.[1] The industries in which chemical processes are of major importance fall among those in which the proportion is relatively low and have been italicized:

Wages as a percent of value added by manufacture

Industry:	*Percent*
Drugs and medicines	10.5
Manufactured gas	11.1
Cigarettes	11.1
Soap	15.4
Paints, pigments, and varnishes	17.4
Flour	19.8
Butter	22.4
Fertilizers	23.3
Chemicals not elsewhere classified	23.8
Explosives	23.9
Blast furnaces	25.6
Cement	27.0
Smelting and refining; copper	29.8
Petroleum refining	30.4
Tin cans	32.2
Sugar refining, cane	33.9
Cutlery and edged tools	35.1
Coke-oven products	37.1
Motor vehicles	37.6
Steam and hot-water heating apparatus	38.8
Paper	38.9
Paper boxes	38.9
Stoves	40.3
Rubber goods, other than tires, inner tubes, and boots and shoes	40.9
Wirework	41.0
Glass	41.1
Structural and ornamental metalwork	41.4
Agricultural implements	42.4
Rubber tires and inner tubes	43.3
Hardware	43.5
Aluminum manufactures	44.6
Cast-iron pipe	44.9
Carpets and rugs	46.8
Baking	47.1
Bolts, nuts, washers, and rivets	47.1

[1] Value added by manufacture represents the value of product less the cost of materials, supplies, containers, fuel, purchased electric energy, and contract works. It measures the net addition to the value of commodities, and is almost completely free from duplications existing in the total value of products.

It does not indicate the percentage which the actual quantity of labor constitutes of the physical volume of production. But the fact that workers in chemical industries receive higher than average wage rates (in 1937 average hourly earnings and average weekly earnings for the chemical industry group were $0.71 and $27.67, respectively, compared with $0.63 and $24.95 for all manufacturing) suggests that the measurement actually overstates the role occupied by labor in chemical production.

Wages as a percent of value added by manufacture—Continued

Industry—Continued.	*Percent*
Clay products, other than pottery	47.2
Clocks, watches, and time-recording devices	47.3
Plumbers' supplies	48.7
Rubber boots and shoes	49.7
Furniture	50.2
Leather	50.4
Lumber	53.3
Steel works and rolling mills	53.5
Sewing machines and attachments	54.5
Woolen and worsted goods	54.6
Boots and shoes	55.5
Shirts	57.7
Foundry products	61.3
Cotton woven goods	63.1
Knit goods	63.4

Source: Computed from *Census of Manufactures,* 1935.

APPENDIX F

TYPES OF PLASTICS AND THEIR USES, 1940

TYPE OF PLASTIC	TYPICAL APPLICATIONS
Shellac plastic	Adhesives, dental blanks for taking impressions, electrical insulation, grinding wheels, novelties, phonograph records, poker chips, protective coatings, thermal insulating board.
Bitumen plastic	Connector plugs on household electrical equipment, handles and knobs for cooking utensils, valve wheels, arc shields, battery boxes.
Phenolic molding plastic	Automotive and airplane parts, camera cases, closures, corrosion-resistant apparatus, electrical insulation, handles, housings, telephone equipment.
Laminated phenolic plastic	Bearings, gears, electrical apparatus, radio equipment, trays, table tops, refrigerator doors, wall coverings, doors, counter and cabinet paneling, translucent and opaque signs.
Casein plastic	Beads, buckles, buttons, game counters, novelties, trimming accessories.
Cellulose-acetate plastic	Airplane cockpit enclosures, automobile accessories, costume jewelry, combs, and toilet articles, electrical appliances, lamp shades and lighting accessories, pen and pencil barrels, radio parts, spectacle frames, transparent containers, watch crystals.
Urea-formaldehyde plastic	Buttons and buckles, closures, containers, illuminated dials, dome and side-wall lenses for automobiles, electrical appliance fittings, hardware trim, piano keys, reflectors, tableware, toys, and novelties.
Cast phenolic plastic	Advertising signs and displays, brush backs, costume jewelry, clock cases, game counters and pieces, novelties, radio housings, lighting fixtures, industrial adhesives, laminating varnishes.

TYPE OF PLASTIC	TYPICAL APPLICATIONS
Vinyl resin plastic	Adhesives, inks, metallic paints, plastic wood-filled compositions, molded articles, cable coverings, coated fabrics, impregnated tape, molded articles, tank linings, cement coatings, films, floor tiles, metal coatings, radio parts, sound records, storage batteries, plating tanks, wallboard coatings, laminated glass.
Polystyrene plastic	Bottle closures, radio parts, refrigerator trim, television parts, transparent automotive accessories.
Acrylic plastic	Adhesives, airplane windshields, decorative articles, dentures, displays, illuminated signs, lenses, protective coatings, reflectors for highway lighting.
Cellulose-acetate butyrate plastic.	Exterior automobile accessories, fishermen's equipment, handles and housings for outdoor uses.
Ethylcellulose plastic	Adhesives, cable coatings, extruded wire insulation, injection molded articles, hot-melt coatings for paper and cloth, pigment grinding base, protective coatings.
Coumarane-indene resin	Mastic floor tile, paper impregnation, protective coatings, rubber compounding, transcription records.

Source: Compiled from the Journal of the Society of Automotive Engineers; May 1940; "Plastics and Their Uses in the Automotive Industry," by Gordon M. Kline.

APPENDIX G

EFFECT ON LABOR OF SPECIFIED TECHNOLOGICAL CHANGES IN TWO TIRE-MANUFACTURING PLANTS

TECHNOLOGICAL CHANGE	EFFECT ON LABOR
3 rubber plasticators installed.	Saving in direct labor, due to increased man-hour output, of 328 man-hours per day, equivalent to displacement of 41 men.
Liquid soapstoning devices installed for Banbury mixers.	1 man per shift, who formerly soapstoned by hand, eliminated. Labor saving, 24 man-hours per day, or 3 men displaced.
Direct method of tire building installed using gum-inserting machines, rotary cutters, compensators, liner stands, etc.	Savings in normal production: (1) Replacement of male with female labor, (2) elimination of time lost by assemblers due to stock changes, (3) direct handling of stock from rotary cutter, (4) elimination of trucking assembled bands to tire room. Saving in direct labor, 248 man-hours per day, or 31 men displaced.
Compensators installed on 40 tire-building machines, and room rearrangement to take care of increased output.	Savings in normal production estimated to exceed 416 man-hours per day, or 52 men displaced.
5 curing units equipped with overhead conveyors, tire removers, etc.	5 men per shift eliminated.
Curing room rearranged to take care of increased production.	Savings in direct labor, when operating at full capacity, 173 man-hours per day, or 22 men displaced.
Preparation conveyor in tube room moved and service conveyor and automatic soapstoning rearranged.	2 girls per shift eliminated, saving 48 man-hours per day.
6 automatic cutters installed on tube preparation unit.	1 girl per shift eliminated.
New tray skids purchased for the handling of tubes and flaps.	2 bookers per shift eliminated.
Banbury mixers installed for 2 tandem calenders.	2 truckmen, 8 millmen, and 6 compounders per day eliminated, saving in direct labor 128 man-hours.

TECHNOLOGICAL CHANGE	EFFECT OF LABOR
Cutting and rerolling departments consolidated and rearranged.	Direct labor saving, 112 man-hours per day, or 14 girls displaced.
Festoons and working platforms erected for the supplying of stock to the automatic unit of tire building.	3 supply girls per shift eliminated, 72 man-hours per day.
20 modern shoulder-drum machines installed to replace old flat-drum machines for building tires.	Direct labor saving 600 man-hours per day, or 75 men displaced.
Tire conveyor extended from building unit to painting machines.	1 trucker and one-half a loading man per shift eliminated, saving 36 man-hours per day.
New system of sorting and assembling tubes installed.	6 girls eliminated, saving 64 man-hours per day.
2 conveyor units, 1 for the purpose of assembling inner tube valves and the others for the testing of valves installed:	5 men and 5 girls eliminated, saving 80 man-hours per day.

Source: U. S. Bureau of Labor Statistics, Bulletin No. 585, *Labor Productivity in the Automobile Tire Industry*, by Boris Stern, July 1933, table II, p. 5.

APPENDIX H

LABOR PRODUCTIVITY AND INDUSTRIAL PRICES

INTRODUCTION[1]

It is the purpose of this appendix to determine the extent to which labor-saving has been offset by price reductions in concentrated as against non-concentrated industries.

To ascertain whether or not labor-saving has been offset by price reductions, the relationship between the behavior of labor productivity and of price is set forth here for nine major industries. Both concentrated and non-concentrated industries are included. The degree of concentration for each is shown in table 1.[2] This approach contrasts for each industry the increase in labor productivity with the use which has been made in the industry of a technique of offsetting that increase—the technique of price reductions. Price reductions are of importance as a compensatory force because (1) Any advances in labor productivity within an industry, unless balanced by increases in production, bring about decreases in man-hour employment and (2) reduction of prices is in economic thought a basic method of increasing demand and output.

TABLE 1.—*Degree of concentration in selected major industries, 1935*

	Degree of concentration, 1935		Value added by manufacture per establishment	
	Largest 4 producers (percent of total)	Largest 8 producers (percent of total)	1929	1935
CONCENTRATED INDUSTRIES				
1. Iron and steel [1]	49.3	63.8	$2,746,000	$1,912,000
2. Non-ferrous metals [2]	(3)	(3)	1,957,000	1,262,000
3. Cement	30.0	44.7	900,000	506,000
4. Motor vehicles [4]	87.0	94.2	6,262,000	4,768,000
5. Cigarettes	89.7	99.4	------------	5,703,000
NON-CONCENTRATED INDUSTRIES				
6. Cotton goods [5]	8.0	14.4	439,000	330,000
7. Woolen and worsted goods [6]	23.1	32.9	448,000	399,000
8. Furniture [7]	5.3	8.8	138,000	75,000

[1] Concentration: Steel works and rolling mills; value added: Crude iron and steel and rolled products.
[2] Value added: Smelting and refining: Copper, lead, and zinc.
[3] Concentration in copper and lead is so high that it cannot be presented because of possibility of disclosure of individual enterprises. Concentration in the zinc smelting and refining industry, by value of product, 64.0 percent.
[4] Concentration: Motor vehicles, not including motorcycles.
[5] Cotton manufactures.
[6] Wool and hair manufactures.
[7] Furniture, including store and office fixtures.

Sources: Degree of concentration—National Resources Committee, The Structure of the American Economy, Part I, 1939, appendix 7. Value added by manufacture—U. S. Bureau of the Census, Census of Manuactures, 1929, 1935.

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[1] This appendix was condensed from parts of a dissertation, "Labor Productivity and Industrial Prices," submitted by the author as partial fulfillment for the degree of doctor of philosophy at the American University Graduate School. For a more adequate treatment, the source should be consulted.

[2] It is to be noted that the first three industries of the concentrated group manufacture producers' goods while the latter two (plus the sixth of that group, the Electric Light and Power Industry) produce consumers' goods; also each group contains producers of durable and of nondurable goods.

The comparison, however, does not carry the suggestion that a given decrease in unit labor requirements means that costs of production declined by that amount and that, therefore, prices should have declined correspondingly. In this report the behavior of price is regarded not merely as an effect but also as a cause of cost behavior. A decrease in price, by stimulating production, would probably bring into play the principle of decreasing costs, thus affecting materially the level of costs. This interpretation of price behavior as cause as well as effect is in obvious conformity with the way in which it is analyzed in this report, namely, in terms of the use made of price reductions as a possible means of expanding output and thereby offsetting the labor-displacing effects of technology.

The comparison of labor productivity to prices also does not carry the suggestion that the price series are a measure over any period of time of the cost of obtaining a given amount of utilities. Price statistics as a whole have not been developed to a point where they measure adequately changes in quality. To cite the obvious example, the automobile of 1937 was not that of 1927. But the price indexes are not used in this report to measure changes in the cost of obtaining a given amount of utilities. They are presented merely to show the extent to which one specific technique, the reduction in the actual price, has been used to enlarge the market. Obviously, there are other methods designed to stimulate sales such as increased advertising, improvements in quality, etc.

It should be pointed out, however, that quality improvements are by no means necessarily tantamount to price reductions. Improvements might be made *ad infinitum* in the quality of an automobile, but if the cash outlay required remains above the purchasing ability of a given income group, no amount of quality improvements could make it possible for members of that income group to purchase the automobile.

The basic principle underlying this study may be summarized as follows:

If in any segment of American industry increased productivity of labor is accompanied by long-term price stability instead of by price reductions, man-hour employment would almost inevitably decline unless some other stimulant to production, such as governmental expenditures, is applied.

THE CONCENTRATED INDUSTRIES

IRON AND STEEL INDUSTRY

Productivity.

The iron and steel industry includes a variety of manufacturing and mining operations up to and including the final fabrication of finished steel products. The definition of the industry could include the extraction of iron ore, but since this operation is usually classified as mining, the iron and steel industry will be regarded as extending back only to the making of pig iron in this study.

Productivity has been increased over the last 2 decades in practically every phase of the iron and steel industry. It has advanced particularly in the three basic processing stages: The blast furnace which extracts the iron from the ore, the open hearth furnace

which produces steel, and the rolling mill from which issue both semi-finished and finished products.

Productivity in the first stage has risen principally through the enlargement of the blast furnace. When the industry was in its infancy, the average blast furnace had a daily capacity of only 5 to 10 molten tons of metal. A modern furnace can produce 1,000 tons of iron a day.[1] This greatly increased production per furnace has not been accompanied by a corresponding increase in workers per furnace. The average mineral fuel stack required 116 men in 1884 and 120 men in 1929.[2]

Man-hour output has been increased also by the reduction of the number of men required to operate a blast furnace plant. This has been accomplished by (1) joint or integrated operation, either of several stacks in one plant or of a blast furnace in connection with a coke plant, or other manufacturing process, and (2) the introduction of labor-saving machinery.

The contribution of joint operation to productivity is apparent. If a plant operates more than one stack, the direct labor is spread over more continuous operation. In handling materials much of the necessary equipment can serve two or more stacks as well as one; casting machines can be kept busy more continuously; pumping power and flowing equipment can be better and more cheaply operated, while floating labor crews can handle maintenance and certain phases of operation to advantage with fewer man-hours per furnace than in a single stack plant.

Three principal labor-saving devices have materially increased output per man-hour. The first is the skip hoist which covers a whole series of improvements in the method of charging a furnace and usually consists of two alternating hoists which convey the materials to the top of the stack and automatically dump them into the furnace. The process greatly reduces the amount of labor needed to charge a furnace. The pig-casting machine displaces a considerable number of sand cutters and iron carriers in the furnace crew and also affects indirectly the labor required in the iron yard, for it facilitates the mechanical loading of the iron pigs. A third labor-saving device consists of two complementary machines—the ore bridge and the car dumper. A car dumper with a crew of two men can handle all the ore for a one or two furnace plant as fast as it can be brought in. Then the ore bridge, with a crew of two operators and two oilers, removes the ore to the stock pile and at the same time keeps the bin supplied with ore for immediate use.[3]

The gains in productivity brought about by these innovations may be ascertained by a comparison of output per furnace and per worker in the years 1884 and 1929–30. In 1884 the average daily output per mineral fuel blast furnace in the United States was 54 tons; in 1930

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[1] National Resources Committee, Technological Trends and National Policy, 1937, p. 331.

[2] Harry Jerome, Mechanization in Industry, National Bureau of Economic Research, New York, 1934, p. 60.

[3] The above data, relating to productivity of labor in blast furnaces, is taken from U. S. Bureau of Labor Statistics, Productivity of Labor in Merchant Blast Furnaces, Bulletin 474, 1928, pp. 24–47. This bulletin cites the reduction of the working day from 12 to 8 hours which took place in 1923, as constituting an additional factor in the increase of output per man-hours.

it was 584 tons. Similarly, the average output per wage earner in 1884 was 170 tons; by 1929 it had risen to over 1,700 tons.[4]

The growth of productivity in the second basic stage of the steel-making process has been somewhat retarded by the increasing demand for steel products of higher quality. The Bessemer process of injecting air through metal revolutionized the steel industry in the middle of the last century and reduced tremendously both the cost and the time of steel making. But the steel produced was not of a high quality and raw materials had to be selected with great care. The Siemens open hearth process, although more expensive and time-consuming than the Bessemer, produced a higher grade of metal and permitted a wider selection of ores. It has therefore practically supplanted the Bessemer process.

In 1890, 86.3 percent of ingots and castings were produced by the Bessemer process and 12.0 percent by the open hearth; by 1939 the percentages had changed to 6.4 and 91.7, respectively.[5]

Principal among labor-saving developments has been the enlargement of the open hearth furnace. Today the modal furnace for the industry has a capacity of from 75 to 100 tons per heat, though large producers in recent years have built open hearths with capacities ranging from 150 to 200 tons. "As in the case of blast furnace operations, fewer wage earners are required to operate these larger units," one authority observes.[6] Automatically uniform regulation of the open hearth furnace is performed by industrial instruments which increase fuel efficiency, reduce the time per heat (thus increasing capacity) and extend the life of the furnace by protecting it against excessive temperatures.[7] In addition, much of the handling machinery and apparatus which have been applied to blast furnaces have also been extended to the open hearth furnaces.

The continuous strip mill, introduced in 1927, is the outstanding improvement in the manufacture of steel. It transforms ingots into finished products by passing them through a series of automatic rolls, eliminating a large number of hand processes formerly necessary to roll the desired shapes.[8] The importance of this development to the industry is obvious. A single continuous mill of the new type can now produce annually more than 400,000 gross tons of uniform gage steel sheets, equivalent to the normal output of 40 or 50 of the old-style mills. In 1929 approximately 1,400 old-style mills had an aggregate annual capacity of only 7,500,000 gross tons of sheets.[9]

The process has been rapidly extended during the last decade. Between 1926 and 1937, 27 continuous sheet and wide strip mills with an aggregate annual capacity of 13,119,000 gross tons were installed by the industry.[10] One prominent engineer has estimated

[4] Harry Jerome, op. cit., pp. 59, 60.

[5] Annual Statistical Report of the American Iron and Steel Institute, 1935 and 1939. The remaining small proportion is composed of crucible and electric processed steel.

[6] Harry Jerome, Mechanization in Industry, National Bureau of Economic Research, New York, 1934, p. 61.

[7] See Works Progress Administration, National Research Project, Industrial Instruments and Changing Technology, 1938, p. 55.

[8] A more detailed description of the continuous strip will be found on p. 111, supra.

[9] Harry Jerome, op. cit., p. 64.

[10] Hearings before the Temporary National Economic Committee, pt. 18, Iron and Steel Industry, Exhibit No. 1349, table XIX, p. 10411.

that 5 modern continuous process mills, put into operation during the early thirties, can now produce with only 130 men an amount of steel sheets which formerly required, under the old type process, over 4,000 men.[11]

At normal utilization of capacity, it is estimated that the continuous mill can effect a reduction in cost of $6 to $8 per ton, and can reduce the rolling-mill labor force per ton of finished steel by 96 percent; of perhaps equal importance, these mills can roll the wide sheets and strips—more than 72 inches in width—in demand for automobile body tops and other uses.[12]

The speed at which rolling mills operate has steadily been increased. In 1939, for example, several tin plate mills were ordered with a maximum speed above 2,500 feet per minute; a year previous a maximum speed of 1,800 feet per minute was a practical limit.[13]

Industrial instruments likewise increase productivity in the continuous mill. In the annealing furnace of a continuous strip mill a single operator is able to survey from a distance a whole array of temperature instruments, and through their recordings to control the operations of the furnace.[14] "The tensiometer provides a certain definite tension in the steel sheets running between the stands of a tandem-plate mill. The electrolimit gage * * * keeps a constant check on the sheets running through the mill." This constant measurement by instrument greatly adds to the efficient operation of a continuous strip mill and eliminates measurement by workmen.[15]

In analyzing the productivity of the iron and steel industry, it must be noted that the degree of productivity varies with the rate of plant operation. During times of curtailed production, productivity drops extensively. The necessity of preventing the deterioration of valuable equipment because of non-use and of spreading the labor over a smaller output, the desire to maintain

Man-hours required to manufacture a gross ton of finished steel products at specified rates of operating capacity[1]

[Average for all finished steel products]

Percent of total plant capacity	Actual average man-hours		Index of man-hours required	
	Manufacture	Administration	Manufacture	Administration
55 to 60 percent	34.43	1.32	100	100
50 to 55 percent	36.15	1.47	105	111
45 to 50 percent	38.22	1.73	111	131
40 to 45 percent	40.63	1.94	118	147
35 to 40 percent	42.34	2.25	123	170
30 to 35 percent	43.73	2.65	127	201
25 to 30 percent	45.10	2.92	131	221
20 to 25 percent	46.48	3.26	135	247

[1] U. S. Bureau of Labor Statistics, Man-hours of Labor per Unit of Output in Steel Manufacture, Monthly Labor Review, May 1935, p. 1161.

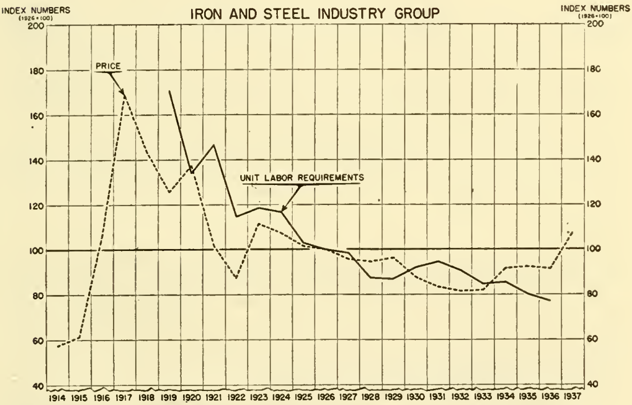
[11] Van Kleeck and Fledderus, editors, On Economic Planning, Covici-Friede, New York, 1935, ch. 14. "Unused Productive and Technical Capacity in the United States," by Walter N. Polakov, p. 226.
[12] Daugherty, DeChazeau, and Stratton. The Economics of the Iron and Steel Industry, McGraw-Hill, New York, 1937, vol. I, p. 19.
[13] Steel, January 22, 1940, "1939 Electrical Developments," by L. A. Umansky, p. 48.
[14] See National Research Project, Industrial Instruments and Changing Technology, 1938, p. 57.
[15] Raymond F. Yates, Machines Over Men, Frederick A. Stokes Co., New York, 1939, illustration facing p. 27.

in employment certain skilled workmen, foremen, superintendents, and other functionaries, and the disappearance of general economies resulting from large-scale operation require a comparatively large amount of labor per unit of output in times of restricted demand. The increase in man-hours required as plant operating capacity declines is shown in the foregoing table:

Reflecting technological developments, the unit labor requirement index for the iron and steel industry (chart I and table 2) shows a general decline during the entire period, 1919–36, marked only by two minor upturns in the post-war depression of 1921–23, and again in 1930–31. These may be ascribed to marked reductions in output, as shown in the table giving the relationship of man-hours required to rate of plant operation.

CHART I

INDEXES OF UNIT LABOR REQUIREMENTS AND PRICES
UNITED STATES



SOURCE: PRICE, AMERICAN METAL MARKET; UNIT LABOR REQUIREMENTS, NATIONAL RESEARCH PROJECT, "PRODUCTION, EMPLOYMENT AND PRODUCTIVITY IN 59 MANUFACTURING INDUSTRIES, 1919-1936," PART II, 1939

In 1919, the unit labor requirement index was at the high level of 170.4 in terms of the 1926 base. In 1920, largely as a result of a material increase in production, the unit labor requirement index dropped to 133.9. It rose again in 1921, as has been noted, when production fell to the extremely low level of 42.0. As production began to increase in 1922, the unit labor requirement index dropped. It rose slightly in 1923 and then dropped steadily to 1929, when it reached a low of 86.9. In 1930, unit labor requirements once more turned upward as a result of decreased production, rising to 94.7 in 1931. But as production picked up following the depression the index again declined. In 1935, the series stood at 80.1 and by 1936 it had dropped to its all-time low of 77.0.

TABLE 2.—*The iron and steel industry*

[1926=100]

Year	Unit labor requirements [1]	Price [2]	Production [1]	Year	Unit labor requirements [1]	Price [2]	Production [1]
1914	------------	57.6	------------	1926	100.0	100.0	100.0
1915	------------	61.7	------------	1927	98.7	95.8	93.8
1916	------------	106.0	------------	1928	87.5	94.7	108.1
1917	------------	168.9	------------	1929	86.9	96.2	118.8
1918	------------	143.5	------------	1930	92.0	87.9	87.4
1919	170.4	125.7	73.2	1931	94.7	83.3	57.1
1920	133.9	137.5	90.9	1932	90.8	81.4	31.5
1921	146.6	101.9	42.0	1933	84.5	81.8	51.9
1922	[illegible]4.8	87.5	73.7	1934	85.3	91.7	58.0
1923	[illegible]8	111.7	92.6	1935	80.1	92.4	76.1
1924	1[illegible]	107.5	77.6	1936	77.0	91.3	105.8
1925	103.[illegible]	101.5	93.3	1937	------------	107.5	------------

[1] Works Progress Administration, National Research Project—Production, Employment and Productivity in 59 Manufcturing Industries, 1919–36, 1939, pt. II.
[2] Weighted average price of steel bars, plates, shapes, pipe, sheets, strips, wire nails, and tin plate, f. o. b. plant, compiled by American Metal Market.

That the long-term decline in man-hour requirements is not due solely to variations in output may be seen by comparing two years of approximately comparable production rates. Production stood at 73.7 in 1922 and at 76.1 in 1935; the unit labor requirements index, however, declined from 114.8 in the former year to 80.1 in the latter. In 1928 and 1936 production was at the relatively high levels of 108.1 and 105.8, respectively. The index of labor required per unit stood at 87.5 in 1928 but by 1936 had dropped to 77.0.

Productivity is rising rapidly in the iron and steel industry. The lowest level of the unit labor requirement index was reached in 1936 and was 11.4 percent below that of 1929, while production was 8.3 percent below 1929.

Price.

Prices may be obtained for many intermediary products in the fabrication of finished steel products, but the quantity of such products sold on the open market is negligible in comparison with the quantity of finished steel products. The price index utilized in this study [16] is a weighted composite of selected finished steel products—bars, plates, shapes, pipe, wire, nails, sheets, strips, and tin plate—compiled by the American Metal Market.

The price index (1926=100) rose rapidly during the first World War from 57.6 in 1914 to 168.9 in 1917. The post-war price decline sent the index to a low of 87.5 in 1922 but it recovered to 111.7 in 1923. By 1925 the index stood approximately midway between these two extremes though at nearly twice the 1914 level. During the 1920's the index was remarkably stable, particularly if a median is computed between the short term low of 1922 and the short term high of 1923. In 1921, for example, the index stood at 101.9; in 1929 at 96.2. This comparative stability was maintained during the depression. Between 1929 and 1932 the series fell only 15.4 percent. By 1934 it stood at 91.7, only 5 percent below the 1929 level, and by 1937 it had risen to 107.5, fully 11.8 percent above the 1929 level.[17]

[16] Table 2, Chart I, supra, p. 239.
[17] The National Research Project presents no data for production in 1937; however, the Federal Reserve Board index shows that steel ingot production was 5.3 percent higher in 1937 than in 1936. Even this increase, if extrapolated, would still result in a figure of production lower in 1937 than in 1929, while price was, as noted, 11.8 percent higher.

The industry has long been cited as an example of a controlled or monopolistic field. In 1935 the four largest firms produced 49.3 percent of the industry's value of product; in terms of capacity, three firms (the United States Steel Corporation, the Bethlehem Steel Corporation, and the Republic Steel Corporation, each of which had a capacity of not less than 4,000,000 tons) held 60.5 percent of the total steelmaking capacity of the United States. In addition, seven smaller firms, with capacities ranging from 1,000,000 to 4,000,000 tons, had 22.2 percent of the steel-making capacity. Thus 88.7 percent of the American steel-making capacity was in the hands of three large firms and seven smaller concerns. Dominating this picture of concentration, however, is one firm, the United States Steel Corporation, with an annual capacity of 27,342,000 tons, or 38.3 percent of the industry's total.[18]

The outstanding characteristic of the steel price structure is the industry's use of the basing point system. This method of arriving at uniform delivered prices was introduced in 1880 by the Carnegie Co. of Pittsburgh and was gradually adopted by the entire industry and extended to practically all steel products. The major change in the basing point system followed the Federal Trade Commission's order in 1924 requiring the United States Steel Corporation to cease and desist from the practice of quoting all prices from Pittsburgh plus freight to destination. It consisted in the substitution of a number of basing points for the single one formerly used.

During the lifetime of the National Industrial Recovery Act the code for the steel industry (adopted in August 1933) embodied three principal characteristics: (1) The basing point practice, (2) the open price method of announcing quotations, generally identical, and (3) a 10-day waiting period, which rather effectively prevented any individual action moderating prices or terms in any manner. In addition, the code contained provisions prohibiting the construction of new capacity and levying fines on producers or distributors who deviated from the accepted price structure.[19]

After a short period of apparent uncertainty at the end of the code period in May 1935, a system of "open prices publicly announced" was reestablished in 1936 for the stated purpose of preventing price demoralization through secret concessions, rebates, and discriminatory prices as between consumers. Iron Age described this as "the most successful stabilizing movement the steel industry has experienced other than the Steel Code." [20] The basing point system was continued, as was the open price method of announcing quotations.[21]

Among the other specific techniques used by the iron and steel industry to prevent departures from the established price structure which might lead to price-cutting and price competition is the extension of price control to include jobbers' resale prices. During the N. R. A. code period, jobbers were severely fined by the enforcing agency, the Iron and Steel Institute, for deviating from the delivered prices set by the basing point system. Before and after the code, compliance

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[18] American Iron and Steel Institute, Iron and Steel Works Directory of the United States and Canada, 1935, pp. 316, 371.

[19] S. Doc. 159, 73d Cong., 2d sess., Practices of the Steel Industry Under the Code, letter from the Chairman of the Federal Trade Commission in response to S. Res. No. 166, 1934.

[20] Iron Age, Jan. 7, 1937, p. 66.

[21] U. S. Tariff Commission, Iron and Steel, Rept. No. 128, second series, 1938, p. 352.

with established prices has been enforced by a virtual blacklisting of those jobbers who quote prices at variance with basing point prices. The industry sells only to "recognized" jobbers and the withdrawal of "recognition" from a jobber usually spells his imminent economic demise.

A second device to insure conformity with established prices is the use of "computed" rather than actual freight rates in setting delivered prices. The freight charges to be added to the base prices are taken from freight rate books compiled by the Iron and Steel Institute. Furthermore, the charges are calculated in terms of all-rail freight, which means that if a cheaper form of transportation is utilized the buyer nonetheless pays a delivered price based upon all-rail freight charges.[22]

A third device is the joint determination by all firms of "extras" which are uniform to the cent. Delivered prices for steel products are made up of three elements: Base price, extras, and freight. Extras are those charges made by the steel producer for variations from a given norm in the physical specifications, chemical analysis, or processing of any steel product. Deductions are usually allowed when quantity purchases are made. Printed schedules of these extras and deductions are issued by the major producers in loose-leaf book form and ordinarily fluctuate even less than the base prices of steel commodities. Whether a change in extras accompanies or is made independently of a change in base prices, the net invoice price is necessarily affected. A reduction in base price accompanied by an advance in extras may produce a net increase in the invoice price.

In the aggregate, extras amount to approximately 10 percent of the delivered price, although for particular commodities the proportion may be much higher. According to an analysis made by the Department of Justice for the Temporary National Economic Committee, the extras in a group of 10 selected commodities shipped in the month of February 1939 amounted to 9.9 percent of the total invoice delivered value of these products. In the case of certain sheets and strips, the proportions amounted to as much as 18.8 and 29.7 percent, respectively. With respect to each of the products examined, the extras and deductions announced by every manufacturer of a product were found to be identical. In some cases lags in publication of changes in extras resulted in differences among producers for limited periods. Otherwise, extras and deductions, as announced, are uniform for all producers throughout the steel industry.[23]

It is theoretically possible for the iron and steel industry to offer more varied, and perhaps lower, delivered prices to its buyers by increasing the number of basing points. There can be no doubt that buyers are in a more advantageous position today under the multiple basing point system than they were under the old Pittsburgh-plus system. Nevertheless,

> in certain respects the multiple-point system is a more efficient device for price fixing than the single-point system. Under it, a competitive insurrection may be quelled, with little danger to the entire price structure, just as a leak in one of the compartments in a modern ship may be confined to that compartment. Disciplinary measures, if necessary, may be focused upon any recalcitrant producer without undue extension of costly results. Such measures may consist of

[22] Federal Trade Commission, Report in Response to Executive Order of May 30, 1934, With Respect to the Basing Point System in the Steel Industry, Nov. 30, 1934, pp. 21–22.

[23] Hearings before the Temporary National Economic Committee, Part 19, exhibit No. 1395, pp. 10724–10728.

reducting base prices (to disastrous levels) if the recalcitrant be a basing-point mill. If not located at a basing point, the recalcitrant may have his mill declared a basing point, whereupon base prices may be cut to any desired level.[24]

The significance of the basing point system in the determination of long-term price behavior is a matter of considerable dispute. On one hand, the Federal Trade Commission maintains that "the basing point system not only permits and encourages price-fixing, but that it is price-fixing." [25] On the other hand, the opinion of such students as de Chazeau and Stratton is that the basing point system is merely one means of exercising the type of control over prices which is inevitable in any industry characterized by the type of markets and technological requirements as the iron and steel industry.[26] Finally, the industry maintains that the basing point system permits competition as fully and completely as any other form of pricing.

Although much may be said in support of each of these contentions, the fact remains that through the use of the basing point system—but not necessarily only because of it—the United States Steel Corporation formulates and establishes prices which are generally followed by its competitors and hence constitute the industry's price structure.[27]

Corroboration of this has been offered by Eugene G. Grace, president of the Bethlehem Steel Co., who testified that—

When we put out a schedule, what we call our official prices, they usually represent and are the same as our competitor has put in the market, and * * * as a general practice that pace is set * * * by the Steel Corporation.[28]

The use of the basing point system, the success of techniques designed to secure adherence to the going prices, and the price leadership exercised by the United States Steel Corporation, are the basic elements which determine the trend of iron and steel prices.

Productivity and Price.

Between 1919 and 1922, both the unit labor requirement and the price indexes declined. Between 1923 and 1929 unit labor requirements fell 26.9 percent (from 118.8 in 1923 to 86.9 in 1929) while price declined but 13.9 percent. In 1927–29 the price series varied only slightly from 95.8 in 1927 to 96.2 in 1929. Yet, the unit labor requirement index declined from 98.7 in 1927 to 86.9 in 1929. For a short time during the depression, the indexes reversed this behavior, for as production decreased, unit labor requirements rose, while at the same time minor downward adjustments were made in the price structure. By 1933–34, the pre-depression relationship reappeared, with the price index turning sharply upward in 1933 and the unit labor requirement series declining. This decline in the unit labor requirement index, interrupted slightly in 1934, continued downward until 1936, when it reached its all-time low of 77.0, while the price index, though relatively constant between 1934 and 1936, turned sharply upward in 1937, reaching a position well above its 1926 and 1929 levels.

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[24] Federal Trade Commission, Report in Response to Executive Order of May 30, 1934, With Respect to the Basing Point System in the Steel Industry, 1935, p. 29.

[25] Ibid., p. 35.

[26] Daugherty, de Chazeau and Stratton, The Economics of the Iron and Steel Industry, McGraw-Hill, 1937, vol. II, pp. 727–732.

[27] Federal Trade Commission Decisions, vol. 8, p. 32, and hearings before the Temporary National Economic Committee, Part 5, testimony of Eugene W. Burr, attorney, Federal Trade Commission, pp. 1860–1901.

[28] Hearings before the Temporary National Economic Committee, Part 19, Iron and Steel Industry, p. 10602.

NONFERROUS METALS INDUSTRY

Productivity.

The most noteworthy advances in productivity in the nonferrous metals industry have been due to a new process of ore dressing or concentration, the selective flotation process.[29] Since this process has been applied in much the same manner to copper, lead, and zinc, analysis of the way in which it has affected copper is sufficient for present purposes.

Prior to the introduction in this country of the selective flotation process in 1911, recovery of copper content in the concentration process was comparatively low. The new process, utilizing chemical attraction instead of gravity and direct oscillation, was first used primarily to reduce losses of copper in the residue of gravity plants. As improvements were made in the selective flotation process, however, it became the major process and by 1927 had practically supplanted the gravity method of concentration. Among the improvements was the use of more effective reagents which increased the speed of floating the minerals and resulted in greater capacities of flotation units and consequent reductions in costs. In general, according to one authority—

> Improved concentration processes employing a variety of reagents not only increased the output of minerals per unit of labor but made possible the utilization of inferior ores, increased the capacity of the mines, decreased the ratio of capital required per unit of mine capacity, and reduced the amount of power consumed per unit of product.[30]

The selective flotation process has also increased the efficiency of primary smelters and refineries, thus affecting directly or indirectly the three operations necessary to convert ore into pigs or slabs of refined metal: Concentration, smelting, and refining.[31] Its principal effects on smelting and refining are—

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[29] The selective flotation process is unique because it utilizes chemical attraction rather than gravity concentration to separate the desired mineral particles in the ore from the waste. In one method, pulp—the mixture of the mineral and the chemical reagent—flows into a cell by gravity through a feed pipe, dropping on top of a rotating impeller. As the pulp cascades over the impeller blades it is thrown outward and upward by the centrifugal force of the impeller. Space between the rotating blades of the impeller and the hood permits part of the pulp to cascade over the impeller blades. This creates a positive suction, through the injector principle, drawing large and controlled quantities of air down through the pipe and into the heart of the cell. This produces a pulp thoroughly aerated with very small air bubbles. These exceedingly small, intimately diffused air bubbles support a large number of mineral particles and carry them to the surface. There the desired mineral is removed as froth. Though there are a number of variations from the flow of operation, the principal features remain basically the same in every type of selective process flow-sheet.

[30] Works Progress Administration, National Research Project, Effects of Current and Prospective Technological Developments Upon Capital Formation, by David Weintraub, 1939, p. 11.

[31] Other developments in the concentration process, of less importance, include: "(1) Improved classification, which has resulted from the introduction of bowl-type classifiers; (2) simplication of crushing flow sheets by larger reduction ratios and production of finer crushing-plant products by the use of cone crushers; (3) use of screens operated in closed circuit with the final stage of crushing, which has produced a uniform maximum size of feed to the grinding mills with marked benefits in grinding operations; (4) substitution of balls for rods in the secondary grinding mills or in both primary and secondary grinding mills and increasing ball and rod-mill speeds, which have resulted in increasing capacities of grinding circuits; (5) regrinding of flotation middling before the return of this product to the flotation cell, which has become common practice and has resulted in improved grades of concentrates; (6) separation of primary slime followed either by the separate conditioning of the primary slime and ground product before the combined products are treated in flotation machines or by the separate flotation treatments of the primary slime and ground product, which has resulted in improved conditioning of the flotation pulps and decreased losses of copper in concentrator tailings; (7) improved conditioning of ore pulps in the treatment of massive sulphide copper ores and reground bulk concentrates, especially the thorough aeration of these pulps before flotation, which has improved the speed of flotation operations when these products are treated." (Bureau of Mines, Bulletin 392, Concentration of Copper Ores in North America, by Thomas G. Chapman, 1936, p. 7.)

(1) It has increased the copper content of the concentrate thus reducing unit labor requirements in smelting and refining. For example, the amount of copper pig produced per man-hour from 100 tons of concentrate with a copper content of 35 percent would of course be greater than that produced from concentrate of 30 percent copper content.

(2) It has encouraged the development of grinding mills, primarily the ball mill, which not only grind at lower cost but more finely than was possible with the equipment utilized prior to the introduction of the flotation process.

(3) It has encouraged the introduction and development of the reverberatory furnace, which generally has replaced the blast furnace in smelting operations, with resultant reductions in the costs of smelting.

Though the technological changes in smelting and refining have been overshadowed in importance by the new process of concentration, one change which has greatly decreased unit labor requirements in these latter stages of the industrial process is the widespread adoption of conveyor systems which transport materials from the ore bin to the roaster and from the roaster to the converter. Trucks have been greatly improved and electrified and are used principally in moving finished pigs. They not only have mechanical arms which slide under and hoist the pigs but also can unload automatically by tilting to almost any desired angle. Modern trucks can handle metal in stacks of over 40 pigs. Thus the amount of labor involved in handling, lifting, and general conveying has been greatly reduced.

A new type of continuous process, insuring continuity of operation and the elimination of complete cooling and reheating between operations has brought about great economies in fuel, time, and floor space, and has contributed to better control.

Automatic charging, improved furnace construction and more efficient means of handling materials have accompanied the replacement of the blast furnace by the reverberatory furnace for smelting and have further increased productivity.

In the refining process, centrifugal pumps for transferring the molten metal from kettle to furnace, improved stirring and skimming machines, straight-line casting machines, pig pullers and stackers for use in connection with the molding wheel, have each contributed significantly to the reduction of unit labor requirements.

In addition to reducing labor expenditure per unit of refined metal, the developments described above have resulted in an increased purity of product, the recovery of a larger percentage of metal from the ore, extraordinary savings in fuel per pound of metal produced, and the recovery of by-products formerly wasted.[32]

Perhaps the outstanding feature of the behavior of the unit labor requirement index is its sharp and almost uninterrupted decline from

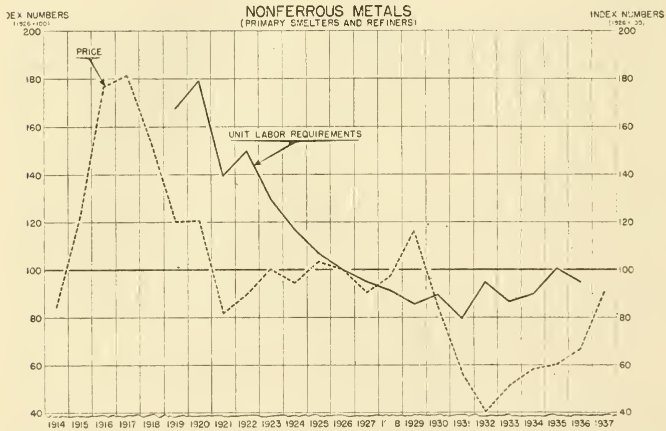
[32] The above description of technological developments in the nonferrous metals industry was taken primarily from Bureau of Mines Bulletin 392, Concentration of Copper Ores in North America, 1936, and Bulletin 381, Lead and Zinc Mining and Milling in the United States, 1935. Additional data were obtained from H. T. Warshow, Representative Industries in the United States, Henry Holt & Co., New York, 1928, pp. 363–366; and National Resources Committee, Technological Trends and National Policy, 1937, p. 168.

1920 to 1930 (see chart II and table 3). The index fell from 178.9 in 1920 to 85.3 in 1929, rising slightly to 89.4 in 1930. Its downward sweep was otherwise continuous during the decade except for an increase of 10 points in 1922 over 1921. With output during the depression greatly curtailed, the unit labor requirement index ceased its rapid descent and rose slightly in 1930 and 1932, but by 1933 it had fallen almost to its 1929 position. Between 1933 and 1935 the index moved upward only to turn downward again in 1936.

CHART II

INDEXES OF UNIT LABOR REQUIREMENTS AND PRICES

UNITED STATES



SOURCE PRICE, BUREAU OF LABOR STATISTICS, UNIT LABOR REQUIREMENTS, NATIONAL RESEARCH PROJECT, "PRODUCTION, EMPLOYMENT, AND PRODUCTIVITY IN 59 MANUFACTURING INDUSTRIES, 1919-1936," PART II, 1939

Although productivity in nonferrous metals varies greatly with the rate of operation, the decrease in unit labor requirements in the last two decades is largely due to techniques which, regardless of output, have increased labor's productivity. In 1924 and 1930 the indexes of production were almost identical but the unit labor requirement index stood at 116.8 in the former year and at 89.4 in the latter.

The long-time gain in productivity may also be observed by contrasting the depression year of 1933, when the production index was 40.3 and the unit labor requirement index was 86.3, with the previous depression year of 1921, when production stood at 42.4 and the unit labor requirement series at 139.5.

TABLE 3.—*The nonferrous metals industry (primary smelters and refiners)*

[1926=100]

Year	Unit labor requirements [1]	Price [2]	Production [1]	Year	Unit labor requirements [1]	Price [2]	Production [1]
1914		84.1		1926	100.0	100.0	100.0
1915		121.5		1927	94.9	90.3	98.8
1916		176.4		1928	91.1	96.9	103.4
1917		181.6		1929	85.3	116.3	112.0
1918		152.9		1930	89.4	84.2	89.8
1919	167.2	120.3	70.9	1931	79.4	56.4	60.2
1920	178.9	120.6	69.2	1932	94.8	40.1	34.3
1921	139.5	81.4	42.4	1933	86.3	51.0	40.3
1922	149.7	89.8	58.3	1934	89.6	58.0	46.8
1923	129.7	100.1	82.0	1935	100.2	59.9	57.4
1924	116.8	94.3	89.9	1936	94.7	66.4	72.0
1925	106.8	103.2	94.5	1937		90.4	

[1] Works Progress Administration, National Research Project—Production, Employment and Productivity in 59 Manufacturing Industries, 1919–36, Part II, 1939.

[2] U. S. Bureau of Labor Statistics. Weighted composite of copper, lead, and zinc ingots, f. o. b. refineries

In 1936 the unit labor requirement index was at 94.7 which may be compared with its position of 94.9 in 1927 when production was 26.8 points above the 1936 level.

Price.

The price index of non-ferrous metals is a weighted composite of copper, lead, and zinc ingot prices. Because of the greater importance of the copper industry, it tends to reflect primarily the movements of copper prices.[33] Nevertheless, the general trend of the index reflects fairly closely the movements of each of the individual series, as lead and zinc prices have tended to behave in much the same manner as copper prices.[34]

Unlike the price index of the iron and steel industry, the non-ferrous metals index was not stabilized after the World War at a level well above its pre-war position. Instead, it dropped precipitously between 1919 and 1921, reaching in the latter year a low of 81.4 as compared with its 1914 level of 84.1. It then turned upward, reaching a level of 103.2 in 1925, though in 1924 it dropped slightly. In 1927 the index dropped to 90.3 but by 1929 it stood at 116.3, the highest level since 1920. During the first years of the depression the index dropped sharply to a low in 1932 of 40.1, slightly more than 50 percent under the previously recorded low of 1921. There followed a gradual rise in the next 5 years and by 1937 the index stood only 9.6 points below the 1926 base.

A high degree of concentration exists in these industries. According to a report on the copper industry by the United States Tariff Commission, "Three groups of capital, no one of which is dominant, together control from 75 to 85 percent of the domestic smeltery capacity and output, the remaining capacity being distributed among half a dozen relatively smaller operators." In addition, "The three capital groups mentioned together control about 80 percent of domestic refining output and capacity, and each has also financial interests in foreign copper production."[35]

[33] The weight of the copper series expressed as a proportion of the total value of all commodities in the Bureau of Labor Statistics wholesale price index amounts to 0.53, as compared to 0.14 for lead and 0.11 for zinc.

[34] For a comparison of world copper, lead, and zinc prices, see Melvin T. Copeland, A Raw Commodity Revolution, Harvard University, Graduate School of Business Administration, Business Research Studies No. 19, 1938, pp. 28–32.

[35] U. S. Tariff Commission, Report to the United States Senate on Copper, Rept. No. 29, 2d series, 19[illegible]

Measured in terms of the value of product, the concentration is so high in the copper and lead industries that no figures can be presented under the Census rule because of the possibility of disclosure of individual firms. In the zinc industry the four largest firms in 1935 produced 64.0 percent of the industry's value of product.[36]

The short-run or immediate determination of prices in these industries is a result of exchanges in a simplified market; the transactions, for the most part, are carried on in New York City, largely by telephone. The uniformity of quality of the product (achieved through the electrolytic process), the relatively small number of sellers and the almost equally small number of principal buyers have tended to bring about this simplified form of marketing. For example, in copper, "the dozen leading buyers probably represent easily three-fourths of the domestic consumption of the metal." [37]

The long-run behavior of prices reflects not only the immediate exchange transactions but also the attempts of the producers to control prices either by the actual fixing of prices or by the supplemental technique of limiting the supply.[38]

In December 1918 the Copper Export Association was formed under the provisions of the Webb Export Act, for the purpose of fixing prices on foreign sales. Most of the principal producers took advantage of this opportunity, and agreed to sell all of their exports through the Association. Although some producers dropped out of the Association after the post-war depression, the objective of controlling the world price was brought nearer to reality by the formation in 1926 of a supplemental organization, the Copper Institute. By the latter part of the twenties, these two organizations had achieved virtually complete control over copper prices. One trade bulletin commented on the situation as follows:

> It must be remembered that a handful of men, controlling 75 percent of the production of copper in the United States, sit around a table and decide what price copper should sell at and any prognostication as to the future price of copper is in reality only a conjecture as to what is in the minds of those gentlemen.[39]

The maintenance of copper prices from April 1929 through March 1930 at the arbitrary level of 17.8 cents a pound, a figure nearly 4 cents above any level reached from 1921 to 1927, in the face of a growing depression, has constituted an oft-repeated story of price-fixing.[40] This pegging of price has been attributed to the efforts of financial interests to increase the value of securities of copper companies in which they were speculating. One prominent financier expressed the opinion that a difference of a cent a pound in the price of copper meant a difference of roughly $1.25 a share in the value of Anaconda stock (or 3 percent of its $50 par).[41]

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[36] See also Yearbook of the American Bureau of Metal Statistics, 1938, pp. 49 and 78.

[37] Warshow, op cit., p. 247.

[38] For details concerning price-fixing in the copper industry, see Hearings Before the Temporary National Economic Committee, Part 25; Frank A. Fetter, The Masquerade of Monopoly, Harcourt Brace, New York, 1931, pp. 197–198; E. G. Nourse and H. B. Drury, Industrial Price Policies and Economic Progress, Brookings, Washington, 1938, pp. 149–156. For a description of N. R. A. code provisions concerning limitations of production and allocation of sales, see National Recovery Administration, Research and Planning Division, Preliminary Report on Codal Provisions Relating to Production and Capacity Control, 1935, pp. 21–22 (unpublished).

[39] F. A. Fetter, The Masquerade of Monopoly, Harcourt, Brace, New York, 1931, p. 198, quoted from Commodity Review, J. S. Bache & Co., Nov. 21, 1929.

[40] See Frank A. Fetter, The Masquerade of Monopoly, Harcourt, Brace, New York, 1931, pp. 197–198; and E. G. Nourse and H. B. Drury, Industrial Price Policies and Economic Progress, Brookings Institution, Washington, 1938, pp. 149–156.

[41] Nourse and Drury, op cit., p. 155.

Regardless of the cause, the price established proved to be too high, and in April 1930 it broke and fell to an all-time low of 4.8 cents by December 1932. The abruptness of the decline was due not only to the extreme height at which the price had been pegged and to the general demoralization of markets created by the depression, but also to the gradual increase which had taken place in the world's actual and potential supply. This increase was due, first, to a remarkable growth in the number of mines developed throughout the world. In Chile, new copper mines rich in ore deposits began producing around 1920 and rapidly expanded their output. In Africa, mines in the Belgian Congo started to produce on a substantial scale in 1920 and within the next 5 years their output increased nearly fivefold. And south of the Congo; in Northern Rhodesia, several mines rich in ore began production in 1931 and 1932.[42]

The second cause of the increased supply lay in the development of the selective flotation process which not only increased the workable output of existing mines but made possible the working of ores which previously had been considered of too low a grade. Thus the new process led to the operation of what is now one of the world's largest lead-zinc mines, the Sullivan Mine in British Columbia.[43]

These increases in potential supply, coming at a time of seriously curtailed demand, resulted in the accumulation of extremely large stocks. This impelled producers to seek ways of controlling, through a limitation of production, the prices at which copper would be sold. At the time the National Industrial Recovery Act was put into effect, stocks of copper had become extremely large. Despite the fact that copper production between 1931 and 1933 had been carried on at rates ranging from 40 to 65 percent below the 1926 level, copper stocks in 1933 amounted to about 2 years' supply.[44]

To meet this situation, a sales pool was organized through which each producer was permitted to sell only the quantity allocated to him. The code also provided that producers should coordinate their production with their sales quota, so that they would both freeze their existing stocks and refrain from enlarging those stocks.[45]

More recently, the increase in the price of copper, the relatively low levels of stocks—despite the great expansion in potential supply and productive facilities—and the allocation among "regular" customers of limited permissible purchases indicate that the corrective measures applied to this industry during the time of the N. I. R. A. have not been completely discarded.

Productivity and Price.

Except for a brief period after the war, the unit labor requirement and the price indexes have followed widely divergent paths. From 1923 through 1928 the price index remained comparatively stable. Yet during this same period, the index of unit labor requirements fell from 129.7 to 91.1, a decrease which, as previously noted, can be ascribed only partially to a rise in production.

This divergence was accentuated in 1929 when the price index reached its post-war high, while unit labor requirements fell to a new

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[42] Copeland, op. cit., p. 2.
[43] Ibid., p. 3.
[44] National Recovery Administration, Research and Planning Division, Preliminary Report on Codal Provisions Relating to Production and Capacity Control, 1935, p. 21.
[45] Ibid., p. 22.

low. It should be noted that this upturn of price, beginning in 1927, paralleled the price-pegging activities of the Copper Institute. Thus, during this period, direct price manipulation was accompanied on the one hand by rising prices and on the other by decreasing labor requirements.

The indexes continued to diverge during the depression, as price plummeted downward because of an increase in available supply and a drastic curtailment of demand, while the unit labor requirement index turned upward because of decreased production.

As recovery set in, the indexes reversed their movements but maintained their inverse relationship. In 1936 unit labor requirements moved downward, while price began an upturn to an 8-year high in 1937. If the indexes continue in their present directions, the 1927–29 relationships may soon be reestablished.

CEMENT INDUSTRY

Productivity.

The gains in productivity in the cement industry reflect almost entirely the progress made in the manufacture of portland cement.[46] In the production of cement, certain raw materials (limes, silica, and alumina) are combined in specified proportions, and are then mixed and ground very fine, either dry or in water. Then intense heat is applied to the mixture in a rotary kiln and the resultant product is known as clinker. After the clinker has been cooled, a small amount of gypsum is added and this mixture is ground very fine to form portland cement.[47]

Continuous technological improvements in the past 30 years have contributed to increased productivity in the industry. Between 1919 and 1937 output of the industry rose from 81,000,000 to 118,000,000 barrels, an increase of 45.7 percent, while the average number of wage-earners rose only 3.5 percent from 25,524 to 26,426.[48]

Gains in productivity have resulted from the construction of new plants, from the enlargement of kiln capacity and the improvement of efficiency in old plants. During the period 1923–32, the increase in the manufacturing capacity of the industry from these causes was as follows: [49]

Annual capacity

	Barrels
New plants built	57, 651, 000
New kiln capacity in old plants	30, 032, 000
Increased efficiency in old plants	26, 214, 000
Total increase	113, 897, 000

The most important technological improvement in the industry has been the rotary kiln. Capable of large output, it created a demand for rapid mechanization in all parts of the industry. The

[46] This study is concerned exclusively with portland cement, as natural masonry and puzzolan cements have comprised not over 2 percent of total cement production in the United States in the past 20 years. (Works Progress Administration, National Research Project, Fuel Efficiency in Cement Manufacture, 1909–35, p. 16, footnote 3.)

[47] Work Projects Administration, National Research Project, Mechanization in the Cement Industry, 1939, p. 3.

[48] Bureau of the Census, Biennial Census of Manufactures, 1931 and 1937.

[49] National Recovery Administration, Division of Research and Planning, The Manufacturing Capacity, Volume, and Costs of Portland Cement in the United States, prepared by H. E. Hilts (Oct. 8, 1934), p. 16, unpublished.

efficiency of the kiln has been steadily improved and its size greatly enlarged. In 1925 only 56 of the 810 kilns in the industry were 200 feet or more in length. In 1935 there were 119 such kilns out of a total of 823.[50] Today there are rotary kilns in operation over 400 feet in length. That this development has increased productivity is shown by a comparison of kiln capacity through three decades. In 1910 the average annual capacity of cement kilns was 134,000 barrels; in 1920 it was 184,000; in 1925, 225,000; in 1930, 296,000; and by 1935 it had risen to 299,000.[51]

To supply sufficient raw materials for large-capacity rotary kilns hand quarrying and loading were no longer adequate, and were replaced by mechanical drills, industrial locomotives, and power shovels. More recent developments in drilling and blasting have been increased mobility of drilling equipment, more efficient application of power, and the use of detachable bits, mechanical sharpeners, better explosives, and improved methods of firing. Alloy materials have increased the durability of drills and are replacing all-steel rigging.[52]

Power shovels and locomotives have advanced labor productivity by increasing the amount of material capable of being loaded and hauled, eliminating firemen, and by reducing labor indirectly associated with loading and hauling operations.[53]

As it became possible to load large pieces of rock, the size of crushers had to be increased. This was effected by the use of vibrating screens between primary and secondary crushers, the "closed-circuit" technique for secondary crushers, and by increasing the effective crushing areas of the crushers, with an accompanying reduction in power.[54]

Larger and more efficient grinding mills were also needed to prepare the increasing quantities of raw materials for feeding the rotary kiln and for grinding clinker into finished cement. In 1900 grinding was done in two stages in two batteries of mills. Since then the old process has been completely changed. Today it is possible to grind more efficiently in one stage instead of two in grinding mills divided into compartments, each designed to grind material to progressively finer degrees. A modern compeb dry-grinding mill, with air separators for classification and transfer of different sized particles into appropriate compartments, can grind as much clinker in the same time that 24 mills of the type in use 30 years ago would have required. Moreover, the clinker can be ground finer with a much smaller consumption of power.[55]

Within the cement mill proper improvements have been made in handling and conveying. The outstanding innovation has been the mixing of finely powdered material with air and moving it in a pipe by the application of pressure. This has resulted in economies in labor and maintenance costs because operation of the valves is automatic by remote control and there are no moving parts.

Similarly, the use of cylindrical or "silo" storage tanks in place of square storage bins has increased the productivity of labor in

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[50] Works Progress Administration, National Research Project, Fuel Efficiency in Cement Manufacture, 1909–35, 1938, p. 39.

[51] Work Projects Administration, National Research Project, Mechanization in the Cement Industry, 1939, p. 53.

[52] Ibid., p. 38.

[53] Ibid., p. 40.

[54] Ibid., pp. 44–46.

[55] Works Progress Administration, National Research Project, Fuel Efficiency in Cement Manufacture, 1909–35, N. Yaworski, V. Spencer, G. Saeger, and O. Kiessling, 1938, pp. 55–57.

handling and conveying. Automatic bagging machines today are able to pack 2,000 bags of cement an hour. Formerly 5 gangs of men, working 10 hours, were needed to accomplish the same task.[56]

The growth in size of equipment in this industry has made it necessary to operate at a high degree of capacity to achieve fully the cost-reducing potentialities of the equipment. The tendency of man-hours required per unit of output to increase as the per-cent of capacity utilized declines—a behavior previously noted in the iron and steel industry—is shown in the following table.

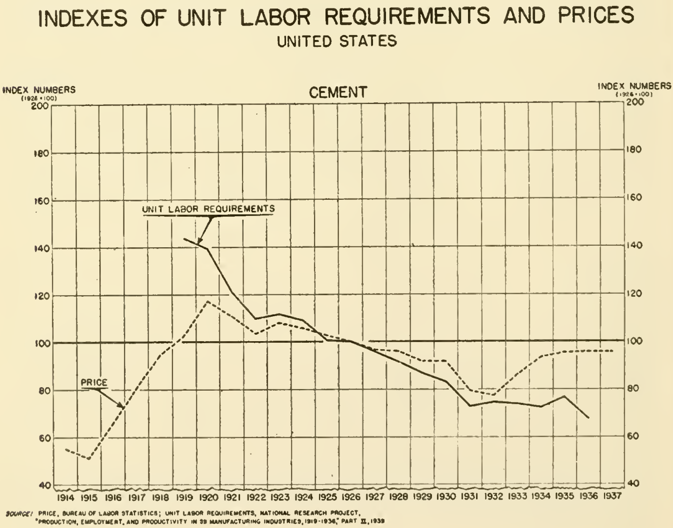
Average effect of reduced capacity utilization on unit labor requirements of individual cement plants[1]

Percentage of capacity utilized:	*Man-hours required per unit of output*
100. 0	100. 0
80. 0	108. 6
60. 0	120. 8
40. 0	140. 4
20. 0	181. [illegible]

[1] Works Projects Administration, op. cit., p. 23.

The unit labor requirement index for the cement industry reflects these improvements in productive processes by a continual, almost unbroken, decline (chart III and table 4). The drop in unit labor requirements was particularly abrupt immediately after the First

Chart III



[56] Works Progress Administration, National Research Project, Mechanization in the Cement Industry, pp. 69–71.

World War, the index falling from 143.7 in 1919 to 109.8 in 1922. The index then began a more gradual decline, which remained unbroken through 1929, except for a slight rise in 1923 and an abrupt decline in 1924–25. During the depression the series remained remarkably stable in view of the above noted tendency of labor required to increase as the percent of capacity in use declines. In 1935 a slight increase in the index took place. This, however, was more than compensated for by a sharp decline in 1936 to 67.2, its lowest recorded level.

The long-time gains in productivity which have taken place, irrespective of the rate of production, may be noted by comparing two years characterized by approximately identical rates of output. In 1922 production stood at 70.2 and the unit labor requirement index at 109.8; by 1936 labor required per unit had decreased to 67.2, with production at 68.9.

The rapid increases in productivity during the twenties are shown by contrasting 1925 when production was at 97.6 and the unit labor requirement index was at 100.6 with 1930, when the corresponding indexes were at 98.2 and 82.9.

TABLE 4.—*The cement industry*

[1926=100]

Year	Unit labor requirements [1]	Price [2]	Production [1]	Year	Unit labor requirements [1]	Price [2]	Production [1]
1914		55.0		1926	100.0	100.0	100.0
1915		51.0		1927	95.9	96.7	104.5
1916		65.4		1928	91.6	95.9	106.8
1917		80.3		1929	86.5	91.8	103.7
1918		94.6		1930	82.9	91.8	98.2
1919	143.7	102.3	49.7	1931	72.5	79.4	75.3
1920	139.5	117.2	60.5	1932	74.3	77.2	46.5
1921	121.2	110.8	59.6	1933	73.5	86.1	38.6
1922	109.8	103.5	70.2	1934	72.0	93.2	47.2
1923	111.6	107.9	83.7	1935	76.6	95.3	46.3
1924	109.1	105.7	90.8	1936	67.2	95.5	68.9
1925	100.6	102.6	97.6	1937		95.5	

[1] Works Progress Administration, National Research Project—Production, Employment, and Productivity in 59 Manufacturing Industries, 1919–36, Part II, 1939.
[2] U. S. Bureau of Labor Statistics.

During the thirties the decline in the two indexes was almost parallel. Production in 1931 was at 75.3 and the unit labor requirement index stood at 72.5; in 1936 production was at 68.9, while the unit labor requirement index had also declined to 67.2.

Price.

The price index utilized is the composite wholesale price series of cement, f. o. b. plant, computed by the United States Bureau of Labor Statistics. The use of a plant price in this study rather than the industry's customary delivered price makes more meaningful a comparison of the trends in productivity and in prices since it eliminates any variations which might occur in delivered prices owing to changes in freight rates.

With 1926 as a base the index rose during the World War years 72 percent (ch. III and table 4). The upward trend continued through the first 2 post-war years until, in 1920, the index stood at 117.2, or

113 percent above the 1914 level. With the exception of 1923 there followed a period of marked stability in the price index during the twenties, the series dropping slightly to a level of 91.8 in 1929. Between 1929 and 1932 the index declined only 15.9 percent and its 1932 level of 77.2 was still 40.3 percent above the 1914 level. From 1932 to 1934 the index rose rapidly to 93.2 and since 1934 it has remained on a plateau of 95.5.

Concentration in the cement industry unfortunately can be measured only in national terms. In 1935 the four largest firms produced only 29.9 percent of the industry's output but, as has elsewhere been pointed out, this figure is probably a deceptive understatement. Competition among the major geographic areas of the country is greatly restricted because of the importance of freight costs; therefore, the degree of concentration within the geographic areas may be (and is) quite high.[57]

The industry furthermore carries on in a vigorous manner certain group activities designed to control prices. These group activities are organized and directed by the industry's trade associations, principally the Cement Institute.

> The Cement Institute, an association of cement manufacturers, was organized in New York City, August 13, 1929, at a meeting of 27 individuals, representing 19 cement-manufacturing companies, 12 of whom signed articles of association, which were declared officially to be operative as of November 1, 1929. During 1930 the institute reached the peak of its effectiveness with a membership of 53 cement-manufacturing companies representing 65 percent of all cement produced during 1930 in the United States.[58]

During the first years of the depression, the membership of the organization slumped somewhat, but at the time of the N. I. R. A. hearings, the institute claimed to represent 95 percent of the members of the industry and 97 percent of its volume of business.[59]

The Cement Institute was formed shortly after the Cement Manufacturers' Protective Association was dissolved. The Cement Manufacturers' Protective Association was organized in 1916 and dissolved in 1924, while the appeal from the dissolution decree against it in the Federal Court was pending in the Supreme Court. An examination by the Federal Trade Commisison has indicated that the Cement Institute is, to all intents and purposes, the same organization against which the Federal Government has proceeded on the basis of alleged violation of the antitrust law.[60]

The industry uses a multiple basing point system to determine delivered prices of its product. Today the cement industry has within the United States approximately 60 basing points, each with its base price. The use of this system has been traced back as far as 1902, at which time freight basing points were established in the Lehigh Valley district and at Hannibal, Mo., for use in the determination of cement prices.

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[57] National Resources Committee, The Structure of the American Economy, Part 1, 1939, p. 115.

[58] S. Doc. 71, 73d Cong., 1st sess., Cement Industry, letter from the Chairman of the Federal Trade Commission, a Report Relative to Competitive Conditions in the Cement Indusry, 1933, p. 98.

[59] National Recovery Administration, Division of Review, History of the Code of Fair Competition for the Portland Cement Industry, by W. A. Janssen, Nelson Dickerman, and K. M. Richards (Sept. 16, 1935), p. 4.

[60] S. Doc. 71, 73d Cong., 1st sess., op. cit., pp. 98–101.

It has been contended that the delivered-price basing-point policy was adopted for the purpose of facilitating the disposal of a rapidly expanding production without breaking down a high mill-price level, because diversion of shipments from one territory to another took place when various levels of prices existed under a system of f. o. b. mill prices.[61] That this purpose was largely accomplished, regardless of whether its achievement depended solely upon the effectiveness of the basing-point system, is indicated by the behavior of the price index for cement. The series during the war increased sharply; during the twenties it was characterized by a marked degree of stability near the wartime levels; and during the thirties its decline was moderate, the index regaining as early as 1934 a position above that of 1929.

Once a multiple basing-point price policy had been generally adopted by the cement industry, manufacturers turned their attention toward maintaining relatively high mill prices; efforts to attain this result through agreement have existed since 1904.[62]

The principal methods used by the cement industry in effectively controlling prices via the basing point system are as follows:[63]

(1) Rate books for every State in the country, showing the carload rate on cement from every basing point which might reasonably affect the price in question, have been distributed to all Cement Institute members. Each producer utilizes, in computing delivered prices, the rate given in the Institute's rate book rather than the true railroad or Interstate Commerce Commission rate. Thus these rate books are instruments for the maintenance of uniform delivered prices and not for the furnishing of complete and accurate information.

(2) The producers have taken definite steps to discourage the delivery of cement by truck, as they believe truck transportation might tend to create price competition. Consumers requiring delivery by trucks are uniformly charged 15 cents per barrel more than customers using rail transportation. The producers have even gone so far as to forbid the loading of cement on trucks furnished by customers.

(3) By means of a so-called "control clause" in their contracts, only delivered prices are quoted to the Federal Government. Under this clause the producers arbitrarily select the route and estimate the rate concession to which the United States is entitled.

(4) The producers have combined to limit their sales only to those middle-men who fall within their agreed and arbitrary definition of a "cement dealer." With a few arbitrarily selected exceptions, no distributor who is not approved by the producers can purchase cement.

(5) The producers, in order to meet the competition of a relatively small volume of cement imported from Belgium and Denmark, have threatened to boycott and have boycotted dealer-customers who trade in imported cement. They have in some cases resorted to espionage upon dealers, and have taken other steps, such as predatory price cutting, designed to minimize or prevent genuine price competition resulting from the importation of cement.

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[61] Ibid., p. 36.
[62] Ibid., p. 36.
[63] Federal Trade Commission, in the Matter of the Cement Institute et al., Docket No. 3167, 1937, pp. 14–17.

By the end of 1931, the 5 largest cement-producing companies owned 59 plants strategically located throughout the country. It has been observed that if these 5 companies with their well-placed mills chose to cooperate directly, they could influence the price of 95 percent of the entire cement output east of the Rocky Mountains.[64]

Productivity and Price.

Perhaps the most apparent characteristic in this comparison between the trend of unit labor requirements and of prices is that the unit labor requirement index has continuously and steadily fallen much more extensively than has the price index. During the entire period 1919–36 the unit labor requirement index declined 53.2 percent while the price series dropped only 6.6 percent. The unit labor requirement index fell very greatly between 1919 and 1922, while the price series fluctuated both upward and downward with the 1922 level slightly higher than that of 1919. During the years 1922–24 the two indexes moved quite similarly, but in 1925 the unit labor requirement series fell abruptly while the price index suffered only a slight decrease. Between 1926 and 1929 the unit labor requirement index dropped 13.5 percent while the price series fell only 8.2 percent.

An abrupt decrease in the unit labor requirement index during 1930–31 was, however, accompanied by a decline in price; and in 1932 as the unit labor requirement index moved up slightly, while price suffered a small decline. Beginning in 1933, however, the price series moved upward rapidly while the unit labor requirement index decreased, and as the price index became stabilized in 1935–36, the unit labor requirement series, after a short upturn in 1935, turned downward and reached in 1936 an all-time low of 67.2.

Thus in 1936 the price of cement was 4.0 percent above its level of 1929, while the unit labor requirement index was 22.3 percent below its position of that year.

MOTOR VEHICLES INDUSTRY

Productivity.

The development of the motor vehicles industry is almost synonymous with the growth of mass production methods. In no other segment of the economy have rationalization, specialization, integration, and general mechanization of the productive processes been more highly developed.

As early as 1903, a multiple drill press had been introduced to work cylinder blocks and heads. In the same year a machine to grind the cylinders themselves, a lathe to turn camshafts, and a vertical turret lathe specially designed to turn flywheels were also developed.[65] Each year has brought gains in productive effectiveness, due not only to the constant development of new machinery but to new methods of material routing, machine layout, and assembling.

Of more immediate importance to this study are the technological developments which have taken place within recent years. A complete catalog of such developments would be entirely beyond the limits of

[64] Federal Trade Commission, Price Bases Inquiry, the Basing-Point Formula and Cement Prices, March 1932, p. 89.

[65] Ralph C. Epstein, The Automobile Industry, A. W. Shaw Co., Chicago, 1928, p. 44.

this study. A few striking technological changes are listed below to give some conception of the reasons for the steadily declining unit labor requirement index in the motor vehicle industry.[66]

1. The complete elimination of wood parts from automobile bodies has greatly reduced labor costs. For example, one manufacturer has entirely eliminated his wood mill which in 1928 employed 3,000 men.

2. The one-piece stamping of the underbody has eliminated the building and assembling of 18 parts found in the 1929 under body, a labor saving of 50 hours in manufacturing and assembling.

3. The one-piece stamping of the top has eliminated the manufacture and assembly of 15 parts and 53 hours of labor.

4. In 1929 an automobile door was made up of 21 parts and cost $4 to assemble. In 1935 the door consisted of one outside and one inside panel; machine welding the two parts together cost only 15 cents.

5. The cost of the body for one popular-priced car was reduced $30 between 1929 and 1935 because of economies similar to those mentioned and many others, notwithstanding the increased amount of steel used.

6. Tungsten carbide tips in various cutting machines have increased the cutting speed of the machines from 180 to 580 feet per minute.

7. In 1929 a well-known automobile manufacturer finished 100 eight-cylinder motor blocks on a given line-up with 250 men. In 1935 the same line-up finished 250 motor blocks with only 19 men, each operator performing about 20 percent more operations. The average pay per 100 blocks in 1929 was $13.20; in 1935 it was $5.20.

8. An automobile manufacturer saved 40 percent of labor in 1935 by boring the wrist pin hole and the crank pin hole of a connecting rod in one operation. Diamond cutting tools doubled the speed of the machine and the holes were rough and finished bored in the same operation.

9. Automatic buffing and polishing machines are rapidly eliminating hand buffing and polishing. One double automatic buffing machine installed in 1933, operated by 1 skilled mechanic and 4 helpers, turned out 12 to 14 thousand pieces a day. Formerly 1 man, working by hand, turned out 600 to 700 pieces per 8-hour day. If the machine were used full time, the labor of 150 men would be eliminated. A single automatic buffing machine, with 1 skilled operator and 2 helpers likewise displaced 150 men.

10. Early in 1934 a roller bearing manufacturer employed about 1,100 men. By 1935 he had eliminated 150 men from his pay roll and increased production 15 percent by speed-up and labor-saving machinery.

11. The change from forging to casting made possible by new alloys has reduced the number of machine operations, and hence the amount of machinery necessary, as well as the cost of casting compared with that of forging. On the new alloy cast shafts 10 operations were eliminated with a 60 percent saving on labor.

12. The use of conveyor systems has been constantly extended in the automobile industry to eliminate trucking and other hand labor.

[66] For a more detailed description of recent technological advances in automobile production, see National Recovery Administration, Research and Planning Division, Preliminary Report on Study of Regularization of Employment and Improvement of Labor Conditions in the Automobile Industry, 1935, appendix B, exhibit 16.

The timing of parts conveyors have been considerably improved so that the arrival of parts at the assembling conveyor is synchronized to avoid storage at that point.

Impressive as the technological advances in the automobile industry have been, new and diversified techniques are constantly being introduced. A number of significant improvements were made in the production of the 1940 models. Entirely new methods of conveyorized assembly have been devised for a number of operations. For example, fenders are now handled by over-and-under chain conveyors, fitted with wood bucks upon which the fenders are placed for dinging, filing, and coarse and fine polishing as they pass a number of workmen. Another improvement is a new method of automatic spot welding bodies which welds a 4-door sedan at 222 points simultaneously. The under-body assembly, the right and left side-panel assembly and the roof assembly are clamped into an assembly fixture and transferred into the equalizing fixture of the automatic multi-welding machine, which spot welds the four huge super-assemblies together.

The basic tool of all machine production, the automatic lathe, has recently been improved considerably in both efficiency and design for use in the production of automobiles. The grinding of "green" rear-axle dry pinions has been eliminated by the installation of three high-production automatic lathes.[67]

Although these very recent improvements are not yet reflected in the unit labor requirement index, their introduction indicates that the rate of decrease in labor required per unit from 1932 to 1936 has probably not abated.

The index of unit labor requirements for the motor vehicle industry reflects closely the constant increases in productive efficiency of this industry (chart IV, table 5). The decline in unit labor requirements from 1919 to 1923 was particularly precipitous, the index falling from 183.8 to 112.5. This decrease has few parallels in any segment of American productive enterprise. From 1923 to 1926 the index flattened out somewhat, although there was a decrease of 12.5 points in the period. This gradual decline continued to 1928 when the series stood at 93.5. An astonishing decrease in unit labor requirements took place in the next year, the index falling to 78.5 in 1929. When production fell to 39.8 in 1932, the unit labor requirement series for the first time in its history moved upward; this increase was substantial as the series reached in 1932 a position only 4.8 points below that of 1926. With increased output, however, the index again turned downward to 78.5 in 1933 and by 1936 reached an all-time low of 67.8. That there has occurred a sharp decrease in unit labor requirements, irrespective of the rate of production, is shown by a comparison of the years 1923 to 1930. In the latter year production was only 1 point above the former, while unit labor requirements had declined from 112.5 to 74.1. Production in 1935 was 3.1 points above the 1926 level but the unit labor requirement index was 30.2 points lower.

[67] American Machinist, Oct. 4, 1939, "Chrysler Girds for '40," pp. 809–820.

CHART IV

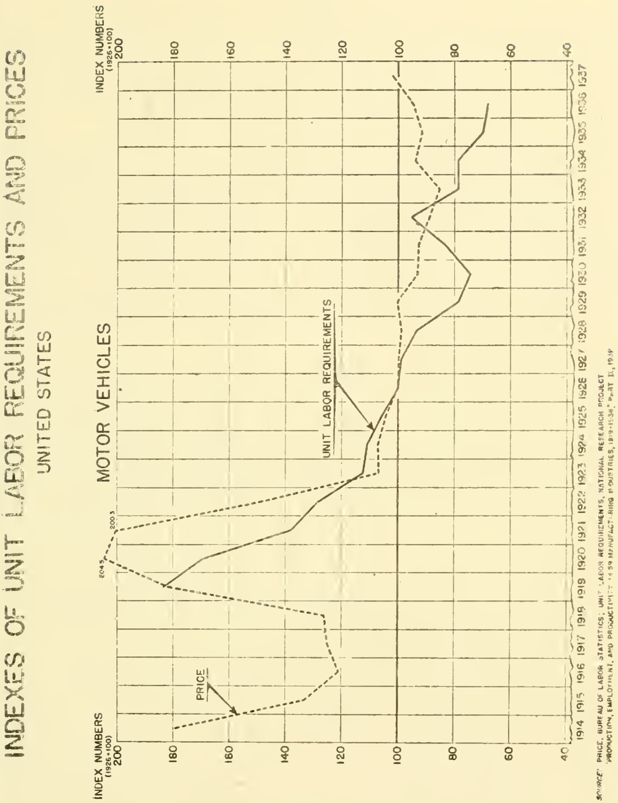

TABLE 5.—*The motor vehicles industry*

[1926=100]

Year	Unit labor requirements [1]	Price [2]	Production [1]	Year	Unit labor requirements [1]	Price [2]	Production [1]
1914		179.4		1926	100.0	100.0	100.0
1915		133.4		1927	98.9	99.8	86.2
1916		121.0		1928	93.5	98.8	110.1
1917		125.0		1929	78.5	100.1	132.6
1918		126.3		1930	74.1	93.1	86.3
1919	183.8	181.9	42.4	1931	83.0	92.7	63.1
1920	169.2	204.5	48.0	1932	95.2	88.9	39.8
1921	138.1	200.3	34.2	1933	78.5	85.1	54.2
1922	128.2	148.5	54.0	1934	78.7	93.8	74.7
1923	112.5	106.9	85.3	1935	69.8	91.4	103.1
1924	110.9	107.2	76.4	1936	67.8	94.7	113.1
1925	105.8	104.3	94.6	1937		101.8	

[1] Works Progress Administration, National Research Project—Production, Employment, and Productivity in 59 Manufacturing Industries, 1919–36, Part II. 1939.
[2] U. S. Bureau of Labor Statistics.

Price.

The price index for this industry is a composite of prices of the standard passenger models of one of the principal low-priced makes. It thus measures the changes which have taken place in the prices consumers have to pay for a new low-priced automobile and reflects rather completely the extent to which producers have endeavored to reach new and wider markets by reductions in prices.

Although the quality of the automobile has undoubtedly been greatly improved over this period, a considerable portion of the changes in models during recent years have affected only style and should, therefore, not affect materially the adequacy of the price index.[68] At all events price indexes, as stated in the introduction, are presented in this study merely to show the use made of one specific technique of enlarging the market, the reduction in the actual price.

The movement of this composite index corresponds generally to the observation of the Federal Trade Commission in its report on the motor vehicle industry, that—

> In general, prices reached the lowest point during the depression years following 1929, but increased somewhat in more recent years.[69]

After reaching a level in 1920–21 of more than 200, about 25 points above its 1914 position, the price index dropped to 106.9 in 1923. This post-war fluctuation marked the end of major changes in the price index, as from 1923 to 1937 the series was remarkably stable. From 1925 to 1926 the index fell 4.1 percent, but for the next 3 years it varied only 1.2 percent. The index fell only 15.0 percent between 1929 and 1933, and then rose from 85.1 in 1933 to 93.8 in 1934. By 1937 the series was slightly above both the 1929 and 1926 levels.

The industry is one of the most highly concentrated segments of our national economy. In 1935 the four largest firms produced 87.3 percent of the industry's value of product.

The growth of concentration is also shown by the sales of the three largest firms, which in 1925 were 63.6 percent of total sales, and in 1937, 88.6 percent of total sales.[70]

Since the formulation of prices for automobiles is a complicated procedure involving estimates of demand, of material, labor and capital costs, and since the costs of various manufacturers could not be expected to be identical because of the various methods of production, similarity of prices among manufacturers would not be expected. The Federal Trade Commission contends that active price competition exists in the low-priced passenger-car field largely because "Ford has never been a member of the powerful motor-vehicle manufacturers' trade group, Automobile Manufacturers' Association, or its predecessor organizations, but followed an independent course with respect to production, price, and sales policies."[71]

However, from 1934 to 1936 the differential in price for comparable Ford and Plymouth models was less than $10 and from 1936 to 1938

[68] As one student of the industry observes, "The industry has contrived ingenious ways for making easily noticed changes without incurring extraordinary expense. The shape and color of fenders and hood, the length of the cowl, the jiggers on the radiator cap, the color of the upholstery, can all be altered annually with but little expense" (Walton Hamilton and Associates, Price and Price Policies, "The Automobile—A Luxury Becomes a Necessity," by Mark Adams, McGraw-Hill, New York, 1938, p. 47).

[69] H. Doc. 468, 76th Cong., 1st sess., Federal Trade Commission, report on Motor Vehicle Industry, 1939, p. 1062.

[70] Ibid., p. 29.

[71] Ibid., pp. 32–33.

it was rarely more than $3 except for 3 months during 1937 when there was a difference of $23 in the prices.[72] This similarity, especially marked in recent years, is shown in the following table:

4-door sedan—F. O. B. factory price, including Federal tax

FORD			PLYMOUTH		
Date of change	Price	Model	Date of change	Price	Model
June 15, 1934	$591.98	V-8	February 1935	$585.99	P J Bus.
Oct. 17, 1935	597.09	V-8.	October 1935	606.51	P 1 Bus.
Nov. 11, 1936	610.73	V-8-85.	November 1936	611.12	P 3 Bus.
Jan. 2, 1937	662.18	V-8-85.	December 1936	665.00	P 3 Bus.
Aug. 2, 1937	687.71	V-8-85.	October 1937	730.00	P 5 Bus.
Oct. 27, 1937	728.11	V-8-85.	April 1938	730.00	P 5 Road King.
Nov. 4, 1938	723.08	V-8-85.	September 1938	726.00	P 7 Road King.

Source: Compiled from the Federal Trade Commission, Report on Motor Vehicle Industry, 1939, pp. 894–6.

Chevrolet prices were practically identical with Plymouth prices on comparable models, which was in line with a statement made in December 1932 by a Chrysler Corporation executive that "Plymouth will go if Chevrolet goes. We don't care about Ford. If we all stuck together the way we always have, we wouldn't care whether he came in or not, but eventually Ford would come in." [73]

Thus the intensity of price competition in the motor vehicle industry seems no greater than in any other concentrated industry surveyed in this study.

Productivity and Price.

Though the price index rose 12.4 percent from 1919 to 1920, it declined 47.7 percent from 1920 to 1923. The unit labor requirement index showed a steady decline from 1919 to 1923, falling 38.8 percent in the 5 years. This followed rather closely the 5-year movement of the price index which registered a decrease of 41.2 percent. In the 4 years following 1923, the unit labor requirement index fell more than the price series, and from 1927 to 1929 the unit labor requirement index dropped from 98.9 to 78.5 while the price index went from 99.8 to 100.1.

During the depression the curtailment of output caused an upturn in the unit labor requirement series, while the price index declined somewhat. This reversal of trend was most conspicuous in 1932, when production had fallen to the extremely low level of 39.8, the price index stood at 88.9 and the unit labor requirement index at 95.2.

After 1932, however, the unit labor requirement index resumed its downward trend, while the price series moved upward. By 1936 the unit labor requirement index was at an all-time low of 67.8, while by 1937 the price index had reached the highest level since 1925.

It would indeed be paradoxical if the automobile industry, long regarded as the outstanding illustration of an industry which translates in prices the benefits of technological advances, were to become characterized by a relationship between productivity and price such that the smaller the number of man-hours required in the production of an automobile, the higher its price.

[72] Ibid., pp. 894–896.
[73] Ibid., p. 34.

CIGARETTE INDUSTRY

Productivity.

The manufacture of cigarettes involves a considerable number of distinct processes. The almost complete mechanization of the principal operations in the productive process from the raw material stage to the final package has resulted in practically automatic manufacture with an extraordinary increase in labor productivity. Improvements are constantly being made which increase the rapidity of manufacture and decrease the unit labor requirements at the various stages of production.

Some outstanding improvements are listed below:

(1) The mechanization of the stemming process was accelerated in the middle thirties by the introduction of a relatively small stemming machine, which, although much less expensive than machines in use prior to that time, was fully as effective as the larger machines and did not depend for low unit costs upon a high volume of output. It has been estimated that these new machines have brought about a decrease of approximately 75 percent in the number of workers formerly employed in hand stemming.[74]

(2) Blending has been considerably speeded up by the use of a wide conveyor belt on which workers place different types of tobacco, each worker placing a certain amount of a single kind of tobacco at a definite rate of speed, instead of the old-style process of piling the various types of tobacco in layers in large bins or on the floor of a large room.

(3) The new casing process by which tobacco is tumbled through a revolving, cylindrical drum and there subjected to the casing solution sprayed from nozzles by compressed air, is measurably superior to the old method of dipping the tobacco into the casing solution.

(4) A new type of cutting device which consists of several knives set in a rotating arbor and does not require re-sharpening every 10 or 15 minutes (the knife-blades being cleaned and sharpened as the machine operates), is almost completely automatic and has greatly increased labor productivity.

(5) A new improved machine capable of making 1,200 to 1,500 cigarettes per minute, while functioning on the same basic principle as the old type of machine that produced 700 to 800 cigarettes per minute, has been widely adopted by the industry in recent years and likewise adds to productivity.

(6) Also, the cigarette industry, like many other industries, has achieved considerable savings in labor expenditures by the extensive use of conveyor belts, supplanting trucking and manual handling.

(7) A further considerable decline in unit labor requirements in the industry is due to an ever-increasing degree of integration and rationalization in the various stages of the productive process. Each function is timed almost to the second. Thus, in modern plants, the tobacco never stops from the time it is placed on the conveyor until it issues from the packaging machine.

The mechanization of the manufacture of cigarettes has attained such a high degree of perfection that the National Research Project observed "In 1937 the cigarette was manufactured and packed, the

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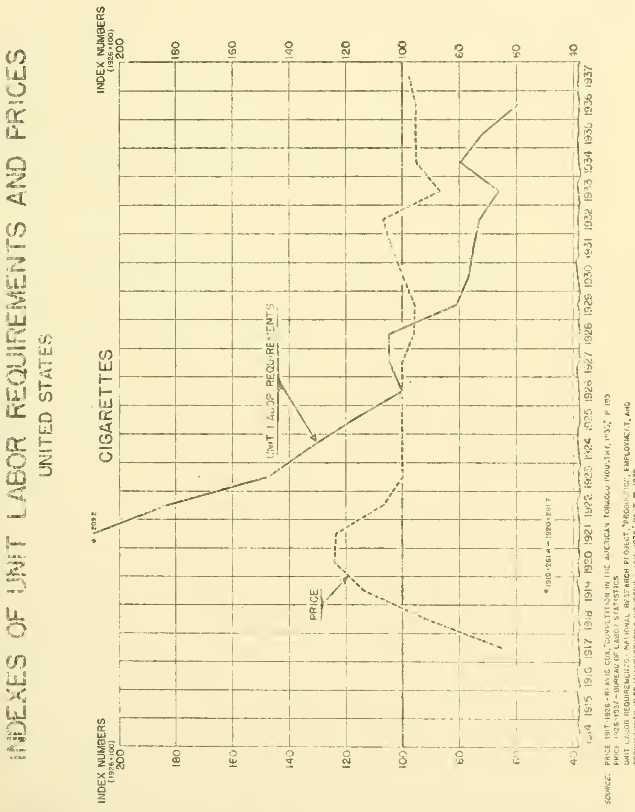
[74] National Recovery Administration, Division of Review, The Tobacco Study, 1936, p. 102–103.

package sealed and stamped, and the stamp canceled by automatic machinery." [75]

The decline in the unit labor requirement index for the cigarette industry from 281.7 in 1920 to 100.6 years later is one of the most amazing advances in productivity in the history of technological development (chart V, table 6). Between 1926 and 1928 this abrupt fall was interrupted by a slight increase, the index rising to 104.8 by 1928. In 1929, however, the index turned down again and declined steadily until 1933. The series rose from 65.9 in 1933 to 79.4 in 1934 and then fell to 71.6 in 1935. This interruption in the decline of unit labor requirements might be ascribed to the loss in the share of the industry's business suffered during those years by the four largest manufacturing concerns at the hands of the smaller, then less mechanized, producers.

CHART V



[75] Works Progress Administration, National Research Project—Production, Employment, and Productivity in 59 Manufacturing Industries, 1919–36, Part II, 1939, p. 210.

TABLE 6.—*The cigarette industry*

[1926=100]

Year	Unit labor requirements [1]	Price [2]	Production [1]	Year	Unit labor requirements [1]	Price [2]	Production [1]
1917		65.1		1928	104.8	95.8	117.9
1918		91.8		1929	80.8	95.4	132.8
1919	261.8	113.5	57.6	1930	76.7	99.7	134.3
1920	281.7	124.0	51.5	1931	74.8	103.4	127.0
1921	209.2	123.7	56.6	1932	72.7	106.8	115.7
1922	183.5	106.9	60.6	1933	65.9	86.6	124.7
1923	147.5	99.9	72.4	1934	79.4	94.9	141.2
1924	133.0	100.0	78.9	1935	71.6	95.1	151.9
1925	117.8	100.0	89.2	1936	59.2	95.1	172.4
1926	100.0	100.0	100.0	1937		97.3	
1927	104.5	100.0	108.4				

[1] Works Progress Administration, National Research Project, Production, Employment, and Productivity in 59 Manufacturing Industries, 1919–36, pt. II, 1939.
[2] 1917–26, Reavis Cox, Competition in the American Tobacco Industry, Columbia University Press, New York, 1933, p. 199. 1926–37, U. S. Bureau of Labor Statistics.

During 1935–36, the index declined more sharply than during 1929–33, but not quite so sharply as during 1923–26. By 1936 the index reached an all-time low of 59.3.

Since the years of slightly decreased production, 1931–33, were accompanied by a steady decrease in unit labor requirements, it may be assumed that the rate of operation, although it undoubtedly affects the degree of productivity, has not been primarily responsible for the tremendous decline in the unit labor requirement index.

Price.

The wholesale price index of the Bureau of Labor Statistics for the cigarette industry reflects the price movements of a number of the major cigarette companies, and as such represents the exchange value of the vast majority of cigarettes sold in this country.

The index, however, goes back only to 1926. For the years 1917–26 an index was computed from the list prices of one of the popular brands.[76]

In the first 4 years the price index increased 90.5 percent, rising from 65.1 in 1917 to 124.4 in 1920. It remained at this level during 1921 but dropped during the next 2 years, reaching a level of 99.9 in 1923.

For the years 1924–27 the index remained at 100. It dropped 4.6 percent in the next 2 years but in 1930 began to move upward. From a level of 95.4 in 1929 the index rose to 106.8 in 1932. This increase came at a time of serious curtailments in economic activity and could not be maintained. The series broke in 1933, dropping to 86.6, the

[76] Reavis Cox, Competition in the American Tobacco Industry, Columbia University Press, New York 1933, p. 199. The prices presented in this work are those of the American Tobacco Co. The propriety of extending the series in this manner is indicated by a comparison of the two series for the years 1926–30.

Year	Bureau of Labor Statistics	American Tobacco Co.
1926	$5.659	$5.689
1927	5.659	5.689
1928	5.442	5.413
1929	5.398	5.376
1930	5.645	5.645

(Both series represent list prices less 10 percent trade discount and 2 percent for cash in 10 days, per M delivered.)

lowest level reached since 1918. Following this break in the price structure, the index rose rapidly in 1934 to a level of 94.9. Since that time it has been maintained at approximately that same level, remaining unchanged for the years 1935–36 at 95.1, and rising slightly in 1937 to 97.3.

The cigarette industry is one of the most highly concentrated major industries in the country. In 1935 the four largest cigarette producers manufactured 89.7 percent of the industry's value of product. This figure of approximately 90 percent is very close to the estimate of the N. R. A. Division of Review that in terms of unit output the three largest manufacturers of cigarettes had practically 91 percent of the total production of small cigarettes for the years 1928–30.[77]

The stability of price is accompanied in the cigarette industry by a striking degree of uniformity in the quotations of the principal producers. For almost six years, up to 1928, there occurred no change in price, but in April of that year the Reynolds Tobacco Co. reduced the price of Camels to $6 per thousand. The other companies followed, Chesterfield and Lucky Strike dropping to the same price. When the next price change took place in 1929, the Reynolds Co. continued its role of leader and announced an increase to $6.40, which was followed by the other major companies. When the price changed again in June 1931, each of the major companies raised its price to $6.85.[78]

This 45-cent increase in price took place at a time when leaf tobacco was at its lowest price since the war and wage rates were suffering from the impact of the depression.

The advance proved to be injurious to the Big Three, for by the end of 1932 they produced only 81.4 percent of the total number of small cigarettes manufactured compared with 91 percent prior to the price increase. During this period of 18 months six smaller manufacturers increased their proportion of cigarette output from 8.2 percent to 16.8 percent. Some of these smaller manufacturers were producers of 10-cent cigarettes.[79]

The high price of $6.85 per thousand, established by the Big Three, was reduced in January 1933 to $6 and was followed one month later by a further reduction to $5.50 per thousand. This was the lowest list price since the war and reflected a definite attempt by the Big Three and the P. Lorillard Co. to regain their former proportion of the business.

The complete uniformity of price determinations by the largest cigarette manufacturers led the N. R. A. Division of Review to point out "the striking adherence to the same list price" and to observe that were it not for a few special allowances, the statement could be made "that competition was not on a price basis." [80] That special discounts are not of sufficient importance to invalidate the price index as a reflector of the actual price trend is shown by the study of chain stores made by the Federal Trade Commission. The Commission found that in 1930 the total allowances to chain stores by all tobacco manufacturers amounted to only 3.57 percent of their sales to these chains.[81]

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[77] National Recovery Administration, Division of Review, The Tobacco Study, 1936, p. 25.
[78] Reavis Cox, op. cit., pp. 206–207.
[79] National Recovery Administration, Division of Review, The Tobacco Study, 1936, pp. 25–26.
[80] Ibid., pp. 24, 27.
[81] Federal Trade Commission, Chain Stores, Special Discount and Allowances to Chain and Independent Producers, Tobacco Trade. S. Doc. 86, 73d Cong., 2d sess., p. 48.

Productivity and Price.

From 1920 to 1923 the unit labor requirement and price indexes both declined though the drop in labor required was much more precipitous than the drop in prices. In the next 4 years the unit labor requirement index declined, though its steady drop was interrupted by slight increases in 1927 and 1928, while the price index remained unchanged through 1927. In 1928 the price index dropped 4.2 percent and remained at about the same level in 1929. The unit labor requirement index resumed its rapid downward course in 1929 while the price series began to move upward in 1930. This inverse relationship continued until 1932. The extent of the divergence is seen by noting that in 1928 the unit labor requirement index was at 104.8 and the price series at 95.8, and that by 1932 the unit labor requirement series had dropped to 72.7 while the price index had risen to 106.8.

In 1933 the unit labor requirement index declined more sharply than it had in the years since 1929. But the price series dropped even more precipitously. In 1934 the unit labor requirement index rose about 20.5 percent while the price index rose only 9.5 percent. This increase in the unit labor requirement index followed and might be attributed to the above noted gain in the proportion of the industry's output made by the smaller, less mechanized, cigarette manufacturing companies.

By 1935, however, the unit labor requirement index was again moving downward, while the price series increased slightly. By 1936 the unit labor requirement index had fallen to its all-time low of 59.3, while the price series, unchanged in 1935 and 1936, was, in 1937, 2 percent above its 1929 level.

ELECTRIC LIGHT AND POWER INDUSTRY

Productivity.

This industry consists principally of commercial and municipal utilities engaged in the generation and distribution of electric current for sale to public or private consumers, the generation of current for sale to other light and power establishments for distribution, or in the distribution of current generated by plants under other ownership. Some of the principal changes in the industry's technology which have increased productivity in power generation, transmission, and distribution are listed below.

(1) In the generation of power, significant advances in productivity have been made in five basic ways.

(*a*) Automatic stoking or the use of powdered fuel equipment for boiler furnaces is now almost universal in the industry. Of the coal burned for the production of electric power in 1928, 97.7 percent was fired mechanically. An example of the reduction in man-hour requirements resulting from the installation of mechanical stokers is afforded by one firm which estimated that about 200 firemen, in three 8-hour shifts, would be required to feed by hand the 24 boilers fed by mechanical stokers attended by 14 employees.[82]

(*b*) Boilers have been improved to use steam at pressures of

[82] U. S. Bureau of Labor Statistics, Monthly Labor Review, August 1932, "Labor Productivity and Displacement in the Electric Light and Power Industry," p. 249 ff.

1,400 pounds per square inch. Less than two decades ago 350 pounds per square inch was the practical maximum.[83]

(*c*) The heating surface of modern generators expressed in square feet is from 8 to 14 times greater than those built in 1900. The rate of evaporation of water per hour in the steam generator has increased from 10,000 pounds in 1880 to more than 1,250,000 pounds in 1935 and steam generator efficiencies have increased from 65 in 1900 to 85 and even 90 in 1935. Furthermore, in terms of unit capacity, modern high pressure and high temperature steam generators are less expensive than the old types of low pressure generators.[84]

(*d*) Today steam turbines with capacities of 160,000 to 212,000 kilowatts are in operation in central electrical stations instead of the formerly used reciprocating steam engines with a maximum of 10,000 kilowatts.[85] In the case of both generators and turbines, the greater output per production unit has resulted in a decrease in the amount of labor required and the improvement in quality and efficiency rating of the equipment has reduced materially the amount of labor needed in maintenance and servicing.

(*e*) Industrial instruments have played an extremely prominent role in the gradual improvement and augmented control of operations in steam electric generating plants, contributing materially to a fourfold increase in fuel efficiency during the past four decades. Accurate measurement has made possible the utilization of higher pressures and temperatures. In addition it has served to protect the equipment itself, for if temperatures are excessive the equipment may be seriously damaged. Instruments are vitally important at eight different stages in the production of power in a modern steam electric-generating station and have contributed greatly to making it almost a completely automatic process. Since the industrial instrument has been perfected to a point where it not only records but also controls the functioning of equipment, the amount of labor required in supervisory and regulatory capacities has been greatly decreased.[86]

(2) In the transmission of power, reductions in the amount of labor have been effected principally through the establishment of unattended, automatic substations and through the development of more durable types of equipment, thus decreasing materially the amount of labor needed in maintenance and repairs.

(*a*) Between 1920 and 1930 the number of unattended substations in 5 representative systems in the United States increased by 320 percent, while the number of attended substations rose by only 41 percent. By 1931, in one large system 72 percent of a total of 325 substations in operation were entirely automatic, while the other 28 percent required some attendance.[87]

(*b*) Transformers with efficiencies approaching 100 percent have been built in tremendous sizes; for example, each of the seven single-phase transformers for Boulder Dam is 55 kilo-volt amperes, 284,000 volts, the highest voltage ever used anywhere except in the laboratory. The oil-circuit breaker and improved insulators have reduced mate-

[83] Power, June 1934, p. 353.
[84] National Resources Committee, Technological Trends and National Policy, "Power," by A. A. Potter and M. M. Samuels, June 1937, p. 257.
[85] Ibid., pp. 257, 258.
[86] Works Progress Administration, National Research Project, Industrial Instruments and Changing Technology, 1938, pp. 60–61.
[87] U. S. Bureau of Labor Statistics, Monthly Labor Review, "Labor Productivity and Displacement in the Electric Light and Power Industry," August 1932, p. 258.

rially the labor required for repair. Cable for underground high voltage transmission has likewise been materially improved through the introduction of new insulating mediums.[88]

(3) In the distribution of power, maintenance labor has been greatly reduced through the joint use of poles by telephone companies and electric utilities in many parts of the country. As in the transmission of power, the amount of labor required in repairing distribution systems has been materially lowered by the development of improved and less expensive transformers. New and improved types of cables and wires have reduced the possibility of breakage or interruption. Finally, the amount of labor required in distributing power has been reduced and will probably be more significantly decreased in the future by the alternating current network system. If one or more supply circuits, or one or more transformers become incapacitated, the other circuits and transformers continue to supply energy to the network without interruption. The development and extension of this type of distribution system has been termed "by far the most important feature in the progress of electric distribution in very recent years." [89]

TABLE 7.—*The electric light and power industry*

[1926=100]

Year	Unit labor requirements [1]	Price [2]	Production [1]	Year	Unit labor requirements [1]	Price [2]	Production [1]
1917	131.4	100.0	40.5	1928	99.2	95.8	121.9
1918		105.5		1929	99.1	93.6	136.1
1919		104.2		1930	103.3	91.9	135.2
1920		107.0	56.7	1931	100.4	91.3	129.5
1921		107.0	53.5	1932	92.9	91.9	114.6
1922	117.2	104.2	62.5	1933	81.6	90.2	118.2
1923	97.5	105.4	73.7	1934	73.9	86.4	127.5
1924	103.8	104.1	78.8	1935	69.3	84.5	138.9
1925	104.6	101.1	88.0	1936	65.4	82.2	160.7
1926	100.0	100.0	100.0	1937	62.7	79.0	177.1
1927	100.4	97.8	111.8				

[1] Works Progress Administration, National Research Project, Production, Employment, and Productivity in 59 Manufacturing Industries, 1919-36, Part II, 1939.

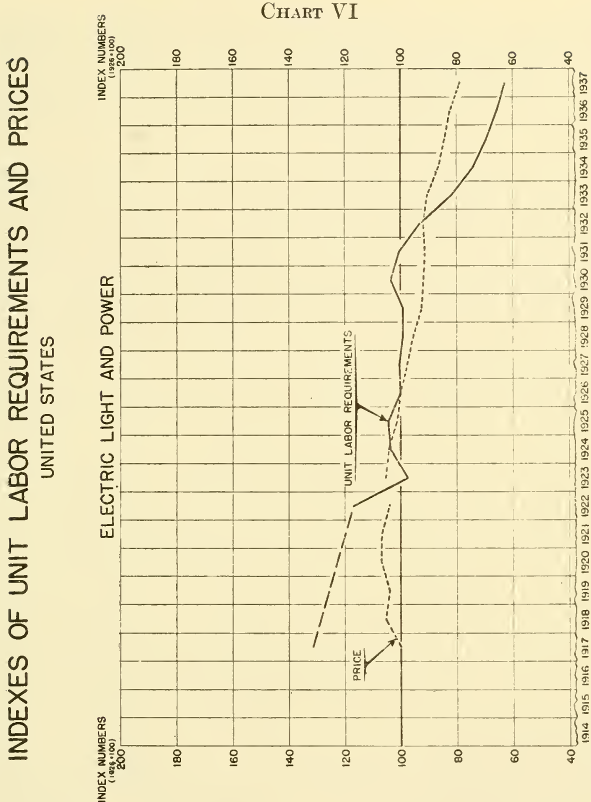
[2] U. S. Bureau of Labor Statistics; 1917-22 December quotations, Retail Prices; 1923-37 annual average of quarterly quotations, Changes in Retail Prices of Electricy; 1923-38, Bulletin 664, 1939, p 2.

The unit labor requirement index reflects these and many other changes which have reduced the amount of labor required in power generation, transmission, and distribution (chart VI, table 7). Although no data are available for the years 1918–21, the unit labor requirements index fell from 131.4 in 1917 to 117.2 in 1922. In 1923 the index fell sharply to 97.5, but from 1923 through 1931, the index remained strikingly constant, never fluctuating more than 6.3 points between any 2 years. The extension of electrical power facilities in those 9 years called for a considerable amount of labor in building new generating systems, transmission lines, and distribution systems. The index seems to indicate that the labor expended for these purposes during this interval offset considerably the savings due to technical improvements made in the actual equipment. But during the depression, when pressure for reduced rates resulted in a drive for lower costs and a relatively small amount of labor was required

[88] National Resources Committee, op. cit., pp. 279, 280.

[89] Ibid., p. 286.

Chart VI



Source: Table 7.

in the extension of transmission and distribution systems, the labor-saving potentialities of improved equipment began to be reflected in a sharp downturn in the index of unit labor requirements. Thus from 1931 to 1934 the index dropped precipitously from 100.4 to 69.3. During 1935–37 this downward trend continued but at a slightly less rapid rate. By 1937 the unit labor requirement index had reached the all-time low of 62.7. That this decline during the thirties had not been due primarily to any change in production but rather to technological advances is indicated by the fact that in 1935 production was only 2.1 percent above the level of 1929, while the unit labor requirement index in 1935 was 30.1 percent below that of 1929.

Price.

The price index used for the electric light and power industry is that of the United States Bureau of Labor Statistics, compiled from residential rate schedules for the typical monthly use of 25

kilowatt-hours. From 1917 to 1922 the series is compiled from schedules showing the price for 25 kilowatt-hours monthly as of December of each year in 32 cities combined.[90] The series from 1923 through 1937 is compiled from retail prices of electricity in 51 cities, an annual average computed from the rate at the end of each quarter.[91] The two series are not strictly comparable but general trends may be noted.

For an analysis of the price data, the typical bill and unit price for the monthly consumption of 25 kilowatt-hours was chosen as most representative of the use of current by the average customer, who does not use major appliances * * *. These data (average number of customers served at specified consumption levels), which were supplied by the Federal Power Commission, reveal that an average of about 60 percent of these customers consumed 60 kilowatt-hours or less monthly. From analyses of consumption habits of thousands of residential customers, it was found that the average consumption for customers using less than 60 kilowatt-hours per month was about 25 kilowatt-hours and that the great majority of these customers used current for lighting and small appliances only. This information supports the choice of the 25 kilowatt-hour service for purposes of price analysis.[92]

Consumption figures for 1937 show that 45.1 percent of residential consumers use 40 kilowatt-hours or less monthly.[93] Since 1937 was a period of relatively high domestic usage of electricity, in preceding years the percentage using 40 kilowatt-hours or less would be even greater. It should be remembered, however, that in recent years, because of the wider use of large appliances, this series would tend to have a slight upward bias. (Yet the very fact that it was only after electric refrigeration had assured an enlarged market that the cost for larger amounts of electricity declined illustrates the nonuse of price reductions by this industry as a means of expanding the market for lighting and small appliances.)

The price index for the first decade under consideration, 1917–26, was remarkably stable, fluctuating not more than 5.5 points between any 2 years. In 1927 a gradual decline began which took the index from 97.8 to 79.0 by 1937. Throughout the 20 years the decline from the high of 107.0 in 1920 and 1921 to the low of 79 in 1937 was only 26.2 percent.

The electric light and power industry is, of course, a regulated monopoly, and, as such, its price behavior reflects not the force of competition but the conflict between the profit-seeking aims of the monopolists and the activities of regulatory bodies. The regulation of public utilities has rested chiefly in the hands of State commissions. Therefore, any study of the price (i. e., rate) behavior of the electric light and power industry must at least note the part played by State commissions in rate setting.

Among the obstacles in the path of effective rate regulation has been the promulgation of the "fair return on a fair value" doctrine. As one authority has said:

The interpretation of fair value has been appealed to the courts on so many occasions and the court holdings have been so consistent that one must say today that fair value is customarily interpreted in terms of reproduction cost new minus depreciation, with more or less—and usually less—consideration of the amounts actually and prudently invested.

The result of the above holdings is that something new under the sun has been set up which is peculiar to the United States—that is, the art and science

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[90] U. S. Bureau of Labor Statistics, Retail Prices, December issue of each year.

[91] U. S. Bureau of Labor Statistics, Changes in Retail Prices of Electricity, 1923–38, Bulletin No. 664, 1939, table 1, p. 2.

[92] Ibid., p. 6.

[93] Ibid., p. 7.

of valuation of property in terms of reproduction cost new. It is a highly specialized art and science, and its refinements have been so developed that it has now become one of the chief means of inflating charges to the consumers of utility services. The practitioners of this art and science have been so successful in crystallizing assumed outlays in connection with the hypothetical formation and upbuilding of companies that one of the New York State commissioners maintained, in the hearings before the investigating commission in 1929, that it was unwise for the commission to press a rate case which might come before the courts, because it would probably result in a valuation of the property concerned that would call for an increase in rates rather than a decrease.[94]

Not only has there been established a hopelessly complex method of making evaluations, but also a very rigid rate of return has been widely accepted. As Mosher goes on to say—

> A survey made in the twenties went to show that a large number of commissions practically accepted 8 percent as the fair return on the assumed investment. Since the depression the rate has been reduced by at least 2 percent and in some cases by 3 percent.
>
> The point at issue here is that a variable rate of return might appropriately be used for the purpose of rewarding companies which operate efficiently and penalizing those which fail to maintain efficient and progressive methods. The commission of Wisconsin should be cited as a notable exception, because it has been attempted to rate the efficiency of the companies subject to its control.[95]

Public utility rate regulation has also suffered greatly from the influences and pressures exerted by political and party interests. The dependence of many commissioners upon party favor for election or appointment has constituted an opening through which utility interests have been able to influence, and often dominate, the attitudes and activities of State commissions.

Principal among the deficiencies in the legislation upon which State utility regulation is based has been the lack of legislative power to deal with vast interstate holding companies. This limitation to intrastate jurisdiction has caused many students to question the ability of State commissions ever to deal adequately with the problem of effectively enforcing rate regulation in the public interest.

These and many other defects in utility regulation would tend to indicate that electric utility companies have been allowed considerable leeway in determining rates. Unhampered by the forces of competition, except in industrial sales, the industry's price behavior reflects the policies of a natural monopoly whose power to impose prices at any levels it desires has only been partially, spasmodically, and ineffectually offset by the efforts of public regulatory bodies.

Productivity and Price.

The productivity-price relationship in the electric light and power industry during the period 1917–37 has been characterized by a number of conspicuous changes. Between 1917 and 1923, the unit labor requirement index fell from 131.4 to 97.5. The price series remained rather constant, increasing 5.4 percent between 1917 and 1923. During 1923–25 the unit labor requirement index rose 7.1 points while the price series fell 4.3 points. The unit labor requirement index turned downward again in 1926 and then remained practically unchanged until 1930 when it rose 3.3 percent over the 1926 level. The price series, however, declined slightly from 1926 to 1930. In the

[94] W. E. Mosher, "Defects of State Regulation of Public Utilities in the United States," The Annals of the American Academy of Political and Social Science, vol. 201, January 1939, pp. 107–108.

[95] Ibid., p. 108.

depression, the unit labor requirement series fell considerably, from 103.3 in 1930 to 81.6 in 1933. In the same period, the price index also declined but to a much lesser extent, falling from 91.9 in the former year to 90.2 in the latter, with the index for 1932 slightly higher than that for 1931. The decline in unit labor requirements continued through 1934 at an abrupt rate and at only a slightly decreased rate during 1935–37. The price index, while steadily declining during this period, did not decrease at all as rapidly as the unit labor requirement series.

Thus, the tendency of the unit labor requirements index to decline more rapidly and extensively than the price series, first manifested during 1917–23, again characterized the 1930–37 movement. The stability of the unit labor requirement index during 1923–29 may be ascribed in part to the wide extension of electric light and power facilities which took place during that period, involving a great deal of construction, erection, and installation of facilities, particularly for the transmission and distribution of electric current. By 1930, however, such facilities had been widely installed throughout the Nation, and consequently unit labor requirements began to decline. This fact, coupled with the technological advances which have decreased the amount of labor required in servicing, maintenance, and current generation, may thus be regarded as the principal explanation for the exceedingly abrupt fall of the unit labor requirement index during the thirties, a decline which from 1930 to 1937 amounted to 39.3 percent.

THE NONCONCENTRATED INDUSTRIES

COTTON GOODS INDUSTRY

Productivity.

Productivity in the cotton goods industry has been increased by varying degrees in its various productive stages, each of which has been characterized by different types of technological innovations. Some of the important changes are indicated below.

In the carding process productivity has been increased greatly by the introduction of automatic blending feeders which blend the raw cotton properly for the production of a uniform product. Machines have been introduced which open and bloom the cotton and remove a high percentage of dirt and leaf. These machines are arranged so that the cotton flows from one to the next automatically, and picking operations, formerly done with three separate machines requiring manual labor at each stage, are now combined in one continuous process. Although few changes have been made in the actual carding machine during the period studied, labor requirements in the carding operation have been diminished through the introduction of controlled humidity and cleaner air, which has resulted in a diminution of difficult start-ups and has thus reduced the amount of manual labor required in the operation of a carding machine.

The most significant technological advances in the entire productive process have taken place in the spooling and warping department. One of the most striking innovations has been the introduction of a traveling device on automatic spoolers which automatically repairs any breaks in the threads. In the warping equipment, three major improvements have been made: (1) the speed capacity of warpers has been increased up to 900 yards per minute, as compared to a

maximum of possibly 70 yards per minute in 1919; (2) the addition to the warper of a magazine creel which, by automatically making available additional material, permits continuous operation; (3) the enlargement of the section beams which has permitted the winding of a larger quantity of yarn per beam. As a result of these changes, practically the only labor required in the spooling process is the comparatively small amount needed to supply the bobbins with yarn and to place them in a slide. Thus, a process which formerly required a large number of workers has been changed to such an extent that the process is today almost completely automatic. This elimination of the human element has made possible a great increase in the speeds at which machinery in the spooling and warping department can be operated, and this in turn has led to a further great decline in unit labor requirements.

In the weaving department, productivity has been increased primarily through improvements in loom construction and design. Breakage of threads has been greatly reduced through the development of more smoothly operating looms. The modern loom is balanced in such a way as to reduce vibrations; it has improved let-off and take-up motions, which insure more evenly woven fabrics; a larger loom beam, which reduces the amount of labor required for warp changing and loom adjusting. It has larger cloth rolls, which permit a reduction of labor in the removal of cloth from the loom. It has redesigned shuttle boxes, which permit the use of larger filling bobbins and thus reduce the frequency of bobbin transfers and loom stoppages at the time of transfer. It has improvements in warp stop motions for the purpose of reducing time required to repair a warp stop; and redesigned and improved shuttle tensions and shuttle eyes, which lessen the loom stops at the time of the bobbin transfer.

The introduction of the automatically controlled shear and brushing machine in the cloth room has increased the speed of this department, as this machine automatically sews the cloth rolls together as they are received and removes loose and hanging threads, thereby materially reducing the work of inspectors. Productivity has also been advanced in this department through an increase in the capacity of the inspecting machines which handle larger cloth rolls direct from the shear, diminishing greatly the manual work incidental to the servicing of cloth rolls in and out of the machine.[96]

The improvement of equipment in the spinning department during the past decade is indicated by the growth of textile production per spindle and by the increase in the hours run per spindle. These trends are shown in table 8.

Although fluctuations in output affect productivity indexes, the trends of output per spindle, and hours run per spindle definitely indicate that during the past decade improvements in quality and operation made in this department have been extensive. Production was higher in 1937 than in 1939 but both output per spindle and hours run per spindle were higher in the latter year than in the former.

There are many factors in the industry such as the multiplicity of separate processes, and the lack of integration, which militated for many years against any material reduction in unit labor require-

[96] The above analysis of productivity changes in the cotton goods industry was compiled from the study by Boris Stern, "Mechanical Changes in the Cotton-Textile Industry, 1910 to 1936," U. S. Bureau of Labor Statistics, Monthly Labor Review, August 1937, pp. 316–341, and from Harry Jerome, Mechanization in Industry, National Bureau of Economic Research, New York, 1934, pp. 80–87.

TABLE 8.—*Yearly production of cotton textiles, production per spindle, and hours run per active spindle, 1930–39*

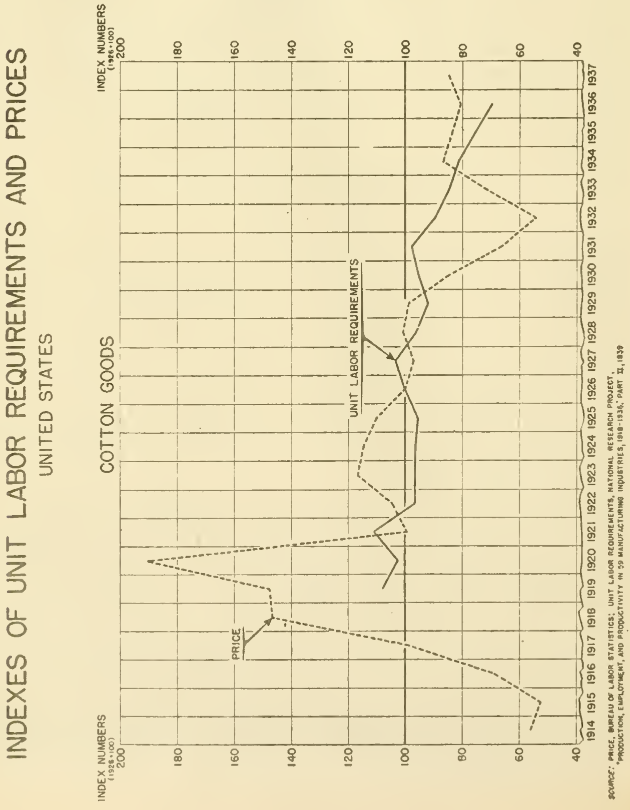
Year	Production in square yards	Average number of active spindles [1]	Average number of square yards per active spindle	Index (1930=100.0)	Hours run per average active spindle	Index (1930=100.0)
1930	6, 448, 392, 000	27, 269, 470	236. 47	100. 0	2, 813	100. 0
1931	6, 955, 391, 000	25, 674, 107	270. 91	114. 6	3, 030	107. 7
1932	6, 278, 222, 000	23, 250, 757	270. 02	114. 2	3, 020	107. 4
1933	7, 866, 040, 000	24, 873, 270	316. 24	133. 7	3, 481	123. 7
1934	6, 878, 579, 000	25, 119, 435	273. 83	115. 8	3, 014	107. 1
1935	7, 135, 276, 000	23, 421, 150	304. 65	128. 8	3, 246	115. 4
1936	8, 613, 837, 000	23, 373, 147	368. 54	155. 9	3, 926	139. 6
1937	9, 445, 736, 000	24, 079, 936	392. 27	165. 9	3, 970	141. 1
1938	7, 502, 168, 000	22, 042, 442	340. 35	143. 9	3, 444	122. 4
1939	9, 145, 765, 000	22, 306, 734	410. 00	173. 4	4, 149	147. 5

[1] Based on 12 monthly reports.

Source: Computed from data assembled by the Association of Cotton Textile Merchants, Journal of Commerce, February 19, 1940, p. 11.

ments. The index exhibits striking stability between 1919 and 1927, reaching its high point in 1921 of 110.9 (chart VII, table 9). For

CHART VII



the next 4 years it was practically stable at the level of 95–96. In 1926 and 1927, the index turned upward and in the latter year stood at 103.3. But in 1928, the series once more moved down to the level of 1922–25 and declined to 91.9 in 1929. This fall in the index was interrupted by an upward movement in 1930 and 1931, when the series reached 97.8.

TABLE 9.—*The cotton goods industry*

[1926=100]

Year	Unit labor requirements [1]	Price [2]	Production [1]	Year	Unit labor requirements [1]	Price [2]	Production [1]
1914		56.0		1926	100.0	100.0	100.0
1915		52.3		1927	103.0	97.1	105.6
1916		68.7		1928	96.1	100.4	94.7
1917		98.7		1929	91.9	98.8	100 7
1918		146.6		1930	95.1	84.7	74.8
1919	108.1	147.5	85.8	1931	97.8	66.1	73.9
1920	102.6	190.7	84.9	1932	89.5	54.0	68.3
1921	110.9	99.5	78.8	1933	84.2	71.2	85.7
1922	96.7	104.3	91.4	1934	81.0	86.5	73.8
1923	96.7	116.9	100.3	1935	75.2	83.4	77.2
1924	96.4	114.7	85.1	1936	69.3	80.3	96.3
1925	95.4	110.0	98.0	1937		84.3	

[1] Works Progress Administration, National Research Project—Production, Employment, and Productivity in 59 Manufacturing Industries, 1919-36, Part II, 1939.
[2] U. S. Bureau of Labor Statistics.

But beginning in 1932 the index started a decline unprecedented in its history and by 1936 unit labor requirements had reached the low level of 69.3.

That no material changes in productivity had taken place prior to this 1932–36 decline is seen by comparing unit labor requirements for 2 years which were characterized by nearly equal rates of production, 1922 and 1928. In the former year production stood at 91.4 and the unit labor requirement index at 96.7, while in the latter year the indexes stood at 94.7 and 96.1, respectively. This stability in unit labor requirements denotes the absence of those changes which bring about any widespread reduction of output per man-hour. That this has been completely reversed in the period 1932–36 is apparent if 1928 is compared with 1936. In 1928 the indexes, as noted, were at 94.7 and 96.1, while by 1936 the production index was at the level of 96.3 and the unit labor requirement index had dropped to 69.3.

Indicative of the rapidity with which unit labor requirements declined during 1932–36 is the fact that although production in 1929 was 4.5 percent higher than in 1936, unit labor requirements in the latter year were 24.5 percent below the level of the former year.

Price.

The price index used in this analysis of price behavior in the cotton goods industry is the cotton goods subgroup of the United States Bureau of Labor Statistics (ch. VII, table 9).

This series rose rapidly during the World War from 56.0 in 1914 to 146.6 in 1918 and continued its precipitous rise through 1920, when it reached the all-time high of 190.7. The index fell abruptly in 1921 to 99.5, or within 43.5 points of the pre-war level. The index rose again in the next 2 years, and by 1923 had reached 116.9, but in 1924

it turned downward, and, with the exception of 1928, declined steadily through 1932. Between 1923 and 1926 the index dropped from 116.9 to 100.0. From 1926 to 1929 the index was comparatively stable, although in the latter year it was 1.2 percent below the level of 1926. The most pronounced stage of this decline took place during the depression, when it declined 45.3 percent between 1929 and 1932. The upturn between 1932 and 1934 brought the index only partially up to the predepression level, and, beginning in 1935, another decline set in, interrupted by only a slight increase in 1937. Indicative of the extent of the long-term decline is the fact that in 1937 the series stood at a level 14.6 percent below the 1929 position and 27.8 percent below the 1923 level.

The cotton goods industry is among the least concentrated of the Nation's important industries. In 1935, the four largest firms produced only 8.4 percent of the industry's value of products.

This lack of concentration arises out of the nonintegrated character of the industry. Few of the mills produce a finished product from the standpoint of the final consumer. For the most part, they merely supply the raw material to the next processing agency. The typical course of a cotton goods product is substantially as follows: (1) From spinning mill to weaving mill, through the agency of a commission house or a yarn broker; (2) from weaving mill to converter via a commission house; (3) from converter to finisher, a transfer of operation but not of ownership; (4) from converter to garment manufacturer, wholesaler or retailer, either with or without the services of a broker. As a result of this separation of functions, the industry is characterized by an extremely complex marketing structure, involving numerous purchases and sales at every stage of the productive process.[97]

The lack of integration among the productive processes has been one of the most important, if not the principal, cause of the industry's highly competitive nature. Mill units are not only widely scattered geographically, but the majority are also small in size, independent in ownership and specialized as to character of output. As the Cabinet Committee said, "The cotton textile industry is faced with difficulties common to all industries characterized by severe competition, causing constant strains and pressures." [98]

The severity of this competition has been steadily increasing. The industry greatly over-expanded its plant and equipment during and immediately after the first World War. With the slackening of demand at the end of the war, the competition for remaining markets became extremely intense. In addition, the industry has been confronted with a slowing down in the per capita consumption of textiles. Despite an increase in population, the total consumption of textiles in general, and of cotton textiles, in particular, has remained nearly stationary during the last decade and a half. Furthermore, substitute textile fabrics, such as rayon, have captured sizable segments of the market formerly held exclusively by the cotton goods industry

[97] United States Cabinet Committee to Investigate Conditions in the Cotton Textile Industry, A Report on the Conditions and Problems of the Cotton Textile Industry, Made by the Cabinet Committee Appointed by the President of the United States. 1935, p. 119

[98] Ibid., p. 1.

The industry's large amount of plant and equipment has made possible the existence of a practice which results in intensifying the severity of price competition, that of the constant purchasing and repurchasing of bankrupt firms. As a result of this practice new competitors may arise in every period of temporarily expanded markets, with the added competitive advantage of being placed in operation under conditions that involve virtually no capital charges.

The individual nature of the various stages in both the productive process and marketing structure militate against the existence of knowledge on the part of most producers as to the size of the market. In consequence, there is no close adjustment of supply to demand in a short-run period, and periodical overstocking occurs which results in serious pressure on prices.

These factors all tend to cause the existence of a relatively large number of very weak firms. Such firms are in continually urgent need of volume at almost any price above lowest attainable costs. Thus, the existence of these weak firms constitutes in itself a source of intense price competition.

Among other sources of competitive rivalry which arise out of the non-integrated nature of the industry is the prevalence of very lenient sales policies. One authority has said that

> producers and distributors * * * tend to become lax in their credit policies in order to increase sales, overlooking the fact that at the same time they enlarge their losses from bad debts. Wholesalers are accused of being too ready to finance retailers whom they hope to see develop into steady customers. * * * Practically all sellers (of every kind) feel a heavy pressure to accept trade abuses perpetuated by their customers, because they are fearful of "losing business," even though a substantial part of the sales * * * yield losses rather than profits.

Producers, for the most part, possess a notoriously "inadequate knowledge of their costs. They are accused of setting their prices at levels which trade custom, or the demands of their customers, or simple hunches may dictate, without regard to whether these prices actually provide a profit." Also, producers in the industry have been forced to assume an increased degree of risk due to the practice of purchasing small quantities at frequent intervals, a policy which increases handling charges and forces producers to provide storage formerly provided by middlemen.[99]

These features, which have contributed to the development of a high degree of competition in the industry, have also been responsible to a considerable extent for the long-term decline in price.

Productivity and Price.

An increase in the price index in 1920 was accompanied by a decline in the unit labor requirement series, while a sharp decrease of 47.7 percent in the price series in 1921 was paralleled by an increase of 7.4 percent in the unit labor requirement index. During the next 4 years, the unit labor requirement index was practically stable, while the price series rose for 2 years and then declined in the next 2 years. In 1926 and 1927, unit labor requirements rose while the price index declined. At the beginning of the depression, a great decline in prices was accompanied at first by a slight increase in the unit labor require-

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[99] Reavis Cox, The Marketing of Textiles, The Textile Foundation, Washington, 1938, pp. 352–353.

ment series but beginning in 1933 the latter index decreased steadily. In 1933 and 1934 the price series moved upward, then dropped again in 1935 and 1936, and rose slightly in 1937.

In 1936 both indexes were at levels well below those of the twenties; except for the depression low of 1932, the price index had reached a level below any previous position since the pre-war period.

The outstanding feature of the relationship between the two indexes during the entire period is the degree to which the general long-term movements have paralleled each other, particularly in their relative stability during the twenties and their downward movements of the thirties. Despite short-term inverse relationships, the indexes over the entire period behaved in a strikingly uniform and parallel manner.

WOOLEN AND WORSTED GOODS INDUSTRY

Productivity.

The fundamental processes of manufacture in the woolen and worsted goods industry are very similar to those of the cotton goods industry. By far the most important from the viewpoint of man-hour requirements is the weaving division. Improvements have also been made, however, in the spinning, the carding, and spooling and dressing department.

The principal technological advances in the industry may be summarized as follows:

(1) In the weaving department, the principal development has been the introduction of the automatic box loom, which replenishes the filling supply without stopping the loom. Thus, the amount of labor required in replenishing the filling supply has been greatly decreased. Another labor-saving feature of the new loom is that it automatically stops whenever a breakage occurs and indicates the position of the broken warp thread. Consequently, the number of looms which a weaver may watch has been greatly increased. These economies have proved so desirable to the industry that by 1938, 25,000 of the industry's 44,000 woolen and worsted looms were of the automatic type.[1]

(2) In the spinning department, the ring frame spindle has replaced the old style mule and has the great advantage that a much larger bobbin may be utilized on it. The increased size of the bobbin has resulted in eliminating a very large amount of the labor required in doffing and in the subsequent spooling and dressing operations.

(3) "Probably the most outstanding mechanical change affecting the production of yarn has been the replacement of the small bobbins or packages formerly used on the mule spinning frame for woolens and cap spinning frame for worsteds by the larger packages now used on the ring spinning frames. Although the yarn-making processes have not undergone any inherent changes, the larger package resulted in greatly reducing the amount of doffing required in 1936 as compared with 1910."[2]

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[1] H. E. Michl: The Textile Industries, the Textile Foundation, Washington, 1938, p. 224.

[2] Boris Stern, "Mechanical Changes in the Woolen and Worsted Industries," 1910 to 1936, U. S. Bureau of Labor Statistics, Monthly Labor Review, January 1938, p. 63.

(4) This utilization of larger packages has made possible a complete change in the mehod of warp dressing in the spooling and dressing department. An entire intermediary process has been eliminated; formerly, warp yarns were first wound from small bobbins to jack spools and then to creels, preparatory to dressing and being wound on the loom beam. Today, high speed cone winders transfer the yarn from the spinning bobbins directly to the cones, which contain more yarn and are more suitable for dressing on the high speed warper.

(5) In the blending and picking department, marked advances have been made by a continuous process which has eliminated the secondary reprocessing formerly needed. Large feeders mix, weigh, and periodically discharge the proper amount of stock on a conveyor which delivers the mixture to the automatic feeder of the Fearnaught picker, the teeth of which separate the wool bunches and mix the fibers.

(6) In the carding department, the principal technological development has been a marked increase in the capacity of the carding machines. This has resulted in a decrease in their number and a consequent reduction in the amount of labor required as tenders. The design and construction of the modern card permit easy and quick adjustment requiring a minimum of maintenance labor. The capacity of the tape codensers which separate the web of wool into ribbons is more than twice that of the old ring doffers which they have generally replaced.

(7) Similar advances have been made in the manufacture of worsted products. The scouring equipment has been greatly increased in size with the result that there has been a material reduction in the number of overseers, drier and scouring men, and soap and chemical men. Greater durability of machinery in the top-making department has resulted in increased output per man-hour because of fewer stops required for repairs and adjustments in the machinery. In the slashing department, the utilization of larger section beams with greater speed and efficiency has resulted in a marked reduction in the number of slash tenders.[3]

The comparative stability in the amount of labor required during the twenties is indicated by the fact that in 1920 the series was at a level of 107.4, while in 1929, the index stood at 104.4, a net decrease of only 2.7 percent (chart VIII, Table 10). After dropping to 107.4 in 1920, the index rose to 115.1 in 1921. From 1922 to 1924 the series declined only slightly from 114.5 to 108.2. In 1925 a somewhat sharper decline occurred. The index however, flattened out in 1926 and for the next 2 years remained on a plateau of about 101. By 1929 the series had increased to within three points of the 1920 level. But in 1930 it turned suddenly downward and continued to decrease to the end of the period, 1936. From a level of 103.6 in 1930 the unit labor requirements index declined to the all-time low of 74.0 in 1936, a decrease of 28.5 percent.

[3] The above analysis of productivity changes in the woolen and worsted goods industry was compiled from Boris Stern, "Mechanical Changes in the Woolen and Worsted Industries, 1910 to 1936," U. S. Bureau of Labor Statistics, Monthly Labor Review, January 1938, pp. 58–93.

CHART VIII

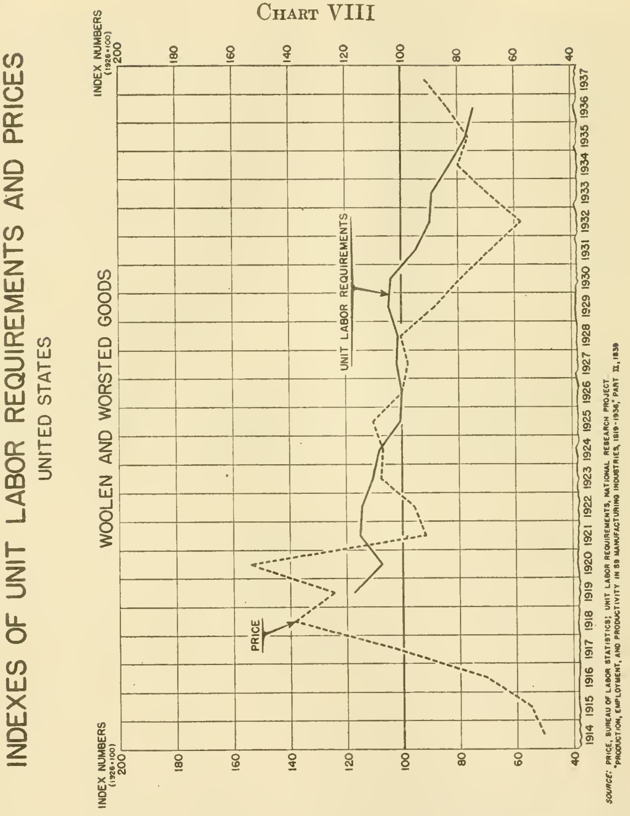

TABLE 10.—*The woolen and worsted goods industry*

[1926=100]

Year	Unit labor requirements [1]	Price [2]	Production [1]	Year	Unit labor requirements [1]	Price [2]	Production [1]
1914		50.5		1926	100.0	100.0	100.0
1915		55.0		1927	101.8	97.8	101.1
1916		70.4		1928	101.2	100.1	95.8
1917		101.7		1929	104.4	88.3	96.5
1918		138.6		1930	103.6	79.0	71.0
1919	117.4	124.3	97.8	1931	94.8	68.2	78.0
1920	107.4	153.7	86.7	1932	89.8	57.7	64.7
1921	115.1	91.9	95.8	1933	89.0	69.3	83.5
1922	114.5	95.7	102.3	1934	82.6	79.7	69.9
1923	110.4	107.5	123.7	1935	76.8	76.1	110.2
1924	108.2	106.8	103.2	1936	74.0	82.9	107.5
1925	100.4	110.2	107.0	1937		91.1	

[1] Works Progress Administration, National Research Project, Production, Employment, and Productivity in 59 Manufacturing Industries, 1919–36, Part II, 1939.
[2] U. S. Bureau of Labor Statistics.

That this rapid diminution in unit labor requirements has taken place independently of the rate of production is indicated in a comparison of 2 years of comparable production rates, 1925 and 1936. In the former year production stood at 107 and the unit labor requirements index at 100.4; in the latter year production was at 107.5, while the index of labor required per unit had dropped to 74.

The recent decline in unit labor requirements in the woolen and worsted goods industry is very similar to that which took place in the cotton goods industry during the same period. This may well be attributed to the fact that both industries are characterized to a great extent by productive mechanisms and functional divisions which bear a very close resemblance to each other.

Price.

The price behavior of the woolen and worsted goods industry (chart VIII, table 10), as represented by the wholesale price subgroup index of the United States Bureau of Labor Statistics, has been quite similar to that of the cotton goods industry.

The index rose greatly during the first World War from 50.5 in 1914 to 138.6 in 1918. After declining 14.3 points in 1919 the index rose to the all-time high of 153.7 in 1920. The post-war depression took the index downward in 1921 to a level approximately halfway between the 1914 and 1920 positions. From 1922 to 1925 the index increased from 95.7 to 110.2. After 1925 the index turned downward again initiating a decline which ended in 1932 at 57.7, or 34.6 percent below the 1929 position. This drop in the series was interrupted only by a slight increase in 1928. The upturn following 1932 brought the series to a position of 79.7 in 1934 and, after a slight decline in 1935, to 91.1 in 1937.

The industry is not characterized by a high degree of concentration, as the 4 largest firms in 1935 produced only 24.2 percent of the industry's value of products. The woolen and worsted goods industry is, however, characterized by a much greater degree of integration than the cotton goods industry. Most mills are completely integrated in the spinning and weaving operations, and practically all of them perform their own finishing. In the industry there are only 4 job printers of woolen goods and less than 50 plants engaged exclusively in finishing woolen goods. The chief finishing process in woolens, known as fulling, cannot profitably be carried out on a large scale, and thus there are no plants specializing in this process.[4]

The functions of a converter are not needed in the industry as woolens and worsteds are given their design in the weave mill and are consequently a finished product upon leaving there. The mills perform their own selling directly to the cutters-up; one study has indicated that approximately one-fifth of men's and women's wool fabrics are sold through wholesalers and jobbers, while at least 70 percent are sold directly by the mills themselves.[5]

The degree of integration is greater in the case of woolen mills than of worsted mills, for in recent years worsted mills have tended to purchase top rather than to make it.

To a considerable extent, this high degree of integration arises out of the individual character of particular woolen weaves. In the

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[4] Graduate School of Business Administration, Distribution of Textiles, Bureau of Business Research, Harvard University, Bulletin No. 56, 1926, pp. 51-52.
[5] Ibid., pp. 51–53.

cotton goods industry, the standard product of the weaving mill, gray goods, is highly uniform. Mills in the woolen and worsted goods industry produce patterns of weaves which are seldom constant, due to ever-changing styles. To meet these style demands a weaving mill in this industry must create new patterns, must test their possibilities by sampling through sales agencies, and must be able to shift its production, at short notice, into new and different weaves.

This last factor is of great significance in the determination of the industry's price behavior as the need for ability to change models on short notice puts a premium on small mills. Although the integration of the woolen and worsted mills results in a comparatively small number of market transactions, the existence of a multiplicity of producers leads to intense price rivalry among them.

Competition in the industry has been intensified by a large amount of excess capacity. During the World War, the woolen and worsted goods industry, like the cotton goods industry, experienced a tremendous increase in demand. This demand did not disappear completely at the end of the war as the demobilization of millions of soldiers who had to be outfitted in civilian clothes created a substantial market for the industry. Furthermore, the export trade was large and apparently expanding. These two facts led to excessive optimism in a large section of the industry and from 1919 to 1925 the number of spindles in place increased from 5,250,000 to over 6,000,000, and the number of looms from 77,338 to 80,629.[6] Capacity was also augmented by the introduction of the previously described automatic loom.

Price competition became extremely severe when the export trade slackened and domestic demand finally decreased after the war, due partially to the decline in per capita consumption of clothing. The trend toward lighter clothing took place at the expense of the woolen industry and to the benefit of the newly developing rayon industry. By the time the woolen industry had developed satisfactory processes of making sheer wool dress fabrics, a considerable portion of its market had been lost to the lighter textiles.

That severe price competition still characterizes the industry is indicated in a recent industry bulletin:

> The delay in the beginning of a recovery movement early in 1938 meant that the mills, in order to get a start on operations for the new season, made desperate efforts to generate business and to obtain orders, particularly from men's wear cloths.
>
> The ordinary method of securing an increase in volume was to make price concessions. This practice, fundamentally unsound in the majority of instances, was carried to such extremes as to mean that most mills, although they booked a reasoniable volume of business, accepted this business at prices which precluded any prospect of profit. The mills are not necessarily to be criticized for this situation. The situation showed, however, the effect of partial operations on profits and indicated what happens when mills in an industry which is more than adequately supplied with machinery, compete on a price basis for a volume of business which is not adequate to provide full employment for that machinery.[7]

Productivity and Price.

The relationship between price and productivity in the woolen and worsted goods industry is similar to that of the cotton goods industry, Except for a dip of 10 points in 1920, the unit labor requirement index

[6] H. E. Michl, The Textile Industries. The Textile Foundation, Washington, 1938, p. 223.
[7] Bulletin of the National Association of Wool Manufacturers, vol. LXVIII, 1938, p. 32.

was comparatively stable from 1919 through 1922. In 1920 the price index went to its all-time high of 153.7 only to drop precipitously to 91.9 in 1921. From 1923 to 1926, the unit labor requirements index declined while the price series rose through 1925 but dropped 10 points in 1926. In 1927 and 1928, the unit labor requirement series was strikingly stable and the price index varied only 2.3 points. However, the price series turned abruptly downward and went to a low of 57.7 in 1932. In 1929–30 unit labor requirements moved upward but in 1931 began a decline which continued through 1936 to the low of 74.0. The price series moved upward in 1933–34, was interrupted by a slight decline in 1935, but by 1937 had reached 91.1.

The long-term decline in the price series of woolen and worsted goods through 1936 compares closely with the behavior of the price series of cotton goods from 1923, and even more closely if taken from 1925. The behavior of the two series of unit labor requirements is also strikingly similar, each showing a slight over-all decline up to 1930, and an abrupt decrease thereafter.

As in the cotton goods industry the long-term movements of the unit labor requirement and the price indexes in the woolen and worsted goods industry have generally paralleled each other.

FURNITURE INDUSTRY

Productivity.

The significant gains in productivity in the furniture industry have taken place principally in the manufacture of household furniture. Although extremely rapid strides have been made in the manufacture of metal furniture, this branch occupies such a small segment of the industry that the index of unit labor requirements must be taken to reflect largely the advances in the manufacture of wooden household furniture.

The most important technological advances have come through plant rationalization. Functions in the manufacture of furniture have been broken down into separate, routinized operations and today the parts flow from one detailed operation to another until the finished commodity emerges as the product of mass production methods rather than that of an individual craftsman's art. The principal technological changes which have taken place in recent years in the four operations of the furniture manufacturing industry may be summarized as follows:

(1) The use of carving machines in woodworking has increased materially both the productivity of the individual worker and the speed of the operation and has also almost completely displaced the old hand carver. Better plant layouts and routinization have synchronized and speeded up the activities of machine operators and miscellaneous handlers. The introduction of the multiple spindle in place of the single spindle carving machine has likewise materially increased the productivity of the workers.

(2) The most noticeable changes involving the elimination of the skilled worker and the segmentation of his many functions have taken place in cabinet making. Formerly, the highly skilled cabinet maker assembled by himself a complete unit of furniture. Today cabinet making is performed by a number of semi-skilled workers, each of whom assembles only parts of a unit, such as the front, sides, or back of a case. The skilled fitter, who fits drawers and doors into

the assembled unit, has resisted routinization more successfully than the cabinet maker but has been forced to speed up his operations because of the rapidity with which the highly specialized assemblers perform their specific functions.

(3) The three functions of the finishing department—sanding, rubbing, and staining and varnishing—have been transformed from hand to machine operations to a considerable extent. The output of individual operators has consequently been greatly increased since the sanding machine, the rubbing machine, and the spray gun are among the most highly productive types of machine equipment introduced into the manufacture of furniture.

(4) The gains in labor productivity in the upholstery department have been made in much the same way as those in cabinet-making. A skilled upholsterer formerly worked on an entire piece of furniture. Today the functions are subdivided so that one group of workers upholsters arms while another group works on backs. This change has eliminated some of the highly skilled workers and has also markedly advanced the speed at which a given unit can be produced. The subdivision of work has not, however, been extended so completely in this department as in cabinet making.

That sweeping technological changes have not taken place in furniture manufacturing is indicated by the slow and gradual decline in unit labor requirements. The necessity of performing many highly dissimilar functions, the bulkiness of the material and its lack of pliability, have raised obstacles to the introduction of any changes which would result in abrupt decreases of labor expenditure.

Immediately after the war, the unit labor requirement index went to its all-time high of 152.4 in 1920 but fell to 123.8 in 1921 (chart IX, table 11). In the next 2 years the index decreased only slightly but in 1924 and 1925, it dropped sharply, reaching a level of 102.4 in the latter year. The series continued to decline through 1929 but in a more gradual manner. In 1930 the series turned upward and with the exception of a slight decline in 1932 rose steadily until in 1933 it stood at 99.5, compared with 91.7 in 1929. In 1934, however, the series dropped to 90.7 where it remained during the next year but in 1936, it rose again to 93.7.

TABLE 11.—*The furniture industry*

[1926=100]

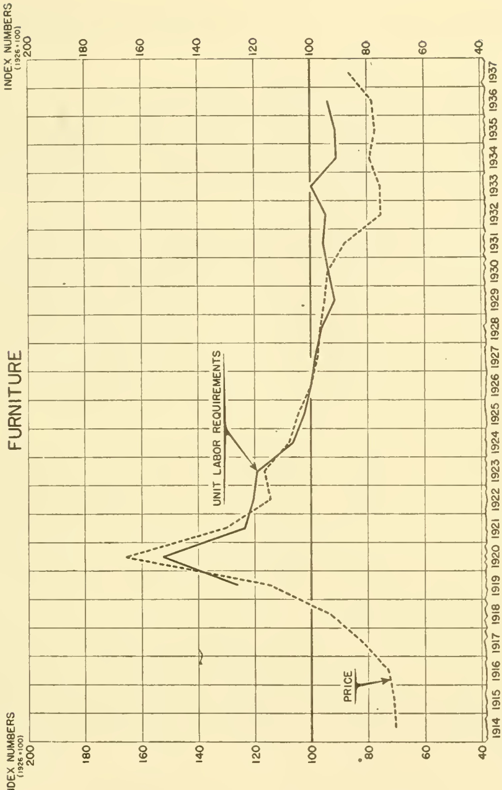
Year	Unit labor requirements [1]	Price [2]	Production [1]	Year	Unit labor requirements [1]	Price [2]	Production [1]
1914		70.6		1926	100.0	100.0	100.0
1915		70.9		1927	98.5	97.7	100.0
1916		72.8		1928	96.2	96.7	98.5
1917		81.7		1929	91.7	95.0	108.5
1918		93.3		1930	93.7	94.0	76.2
1919	126.1	114.7	59.8	1931	95.3	88.0	58.4
1920	152.4	165.6	52.1	1932	94.7	75.0	39.7
1921	123.8	129.9	48.9	1933	99.5	75.1	42.1
1922	120.6	114.6	65.0	1934	90.7	79.0	47.2
1923	119.2	116.7	74.5	1935	90.9	77.0	61.3
1924	106.3	107.9	80.0	1936	93.7	78.0	72.1
1925	102.4	104.6	92.1	1937		85.9	

[1] Works Progress Administration, National Research Project—Production, Employment, and Productivity in 59 Manufacturing Industries, 1919-36, pt II, 1939.
[2] U. S. Bureau of Labor Statistics.

CHART IX

INDEXES OF UNIT LABOR REQUIREMENTS AND PRICES

UNITED STATES



SOURCE: PRICE, BUREAU OF LABOR STATISTICS; UNIT LABOR REQUIREMENTS, NATIONAL RESEARCH PROJECT, "PRODUCTION, EMPLOYMENT, AND PRODUCTIVITY IN 59 MANUFACTURING INDUSTRIES, 1919-1936," PART II, 1939

Productivity varies in this industry quite closely with the rate of production. The marked decrease in productivity during 1923–26 was accompanied by a rapidly rising rate of output, as the production index rose from 74.5 in the former year to 100 in the latter. In 1929, when the unit labor requirement index had reached its lowest level up to that time, production was at the highest level yet attained. Nevertheless, a significant long-term decline in unit labor requirements has taken place in the industry independent at the rate of production. This is indicated by a comparison of two years of comparable production rates, 1922 and 1935. In the former year, production stood at 65.0 and unit labor requirements at 120.6; by 1935 labor required per unit had decreased to 90.9 though production was at 61.3.

In 1934 when the unit labor requirement series reached its all-time low of 90.7, production was 56.5 percent below the 1929 level. This

may be taken to indicate the widespread introduction during the depression of numerous changes designed to reduce labor expenditures.

Price.

The price index used in this study is that of the furniture subgroup of the United States Bureau of Labor Statistics. This composite index reflects primarily the price behavior of wooden household furniture, although other types of furniture, principally metal, are included and weighted according to their value in exchange (chart IX, table 11).

A marked increase in the price of furniture took place during the World War, the index rising from 70.6 in 1914 to 93.3 in 1918. The index continued upward through 1920 when it reached the all-time high of 165.6. Although the series dropped abruptly in the next 2 years to 114.6 in 1922, it still remained 34 percent above the pre-war level. The height to which furniture prices rose during and after the war and their failure to drop back immediately to their pre-war level brought forth a Senate resolution in 1922, directing an investigation by the Federal Trade Commission into prices, markets, and profits in the furniture industry.[8]

After a slight upturn in 1923, the index fell from 116.7 in 1923 to 100 in 1926. A steady, more gradual decline in the price series continued through 1930. In the next 2 years the index dropped abruptly and in 1932 was at 75, or 21.1 percent below the 1929 level. It remained at this low level during 1933, turned upward in 1934 and fluctuated between 79 and 77 for 3 years. In 1937 the series reached a level of 85.9 which was, however, considerably below the pre-depression level.

The household-furniture industry is divided into two classes of manufacturers: The integrated producers and those who specialize in one line and buy from other manufacturers the pieces needed to complete a suite. As early as 1922, the Federal Trade Commission reported that, "There is a tendency in the industry for companies manufacturing specialized lines to integrate or to become affiliated in order to manufacture complete suites for bedroom, living room, and dining room." [9]

The manufacture of furniture is one of the least concentrated of the Nation's major industries; in 1935, the four largest concerns produced only 5.6 percent of the industry's value of product. This lack

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[8] The role which the level of prices played in provoking this investigation is to be noted in the wording of the resolution adopted by the Senate on January 4, 1922:

"Whereas reported statistics show that the prices of house-furnishing goods reached a higher peak relative to pre-war prices than any other class of commodities; and

"Whereas since May 1920, while most other reported classes of commodities were falling in price, the prices of house-furnishing goods continued to increase until the latter part of 1920, and then registered only a gradual decline; and

"Whereas the prices of house-furnishing goods are now relatively very much higher than any other class of commodities, and particularly are relatively more than twice as high as the prices of farm products: Therefore be it

"*Resolved,* That the Federal Trade Commission be, and hereby is, authorized and directed promptly to investigate the causes of factory, wholesale, and retail price conditions in the principal branches of house-furnishing goods industry and trade, beginning with January 1920, and particularly to ascertain the organization and interrelations of corporations and firms engaged therein, and whether there have been and are unfair practices or methods of competition, or restraints of trade, combinations, or manipulations, out of harmony with the law of public interest; and if so, what effect the same have had on prices; and, serially, to report the facts, with its recommendations, at the earliest possible time as different phases of the investigation are completed." (Federal Trade Commission, House Furnishings Industries, vol. I, Household Furniture, 1923, p. 1.)

[9] Ibid., p. 44.

of concentration is accompanied by a high degree of price competition. Causes for keen competition lie in:

(1) A large amount of productive equipment considerably expanded through 1929 to take care of a backlog in furniture demand created during the World War and the rapid increase in residential building between 1921 and 1925. This greatly increased productive capacity came to weigh heavily upon the industry when its markets during the thirties were gradually and then sharply curtailed.

(2) Decentralization has grown in the industry in recent years due largely to new methods of merchandising. Formerly most retailers placed large orders with manufacturers and then tried to dispose of these extensive stocks. The retailer has found that he is able to attract more customers by offering a wide selection of furniture as to material and color. In order to satisfy this varied demand without carrying on hand a tremendous stock of merchandise, which would decrease his stock turnover and increase his losses from shop wear and markdowns, the retailer has found it advantageous to stock only a few patterns as samples from which orders can be taken for delivery within a short time. This has put a premium upon the rapidity of manufacture and upon strategic locations. The development of trucking has facilitated this method of merchandising furniture. In order to meet the competition of small local manufacturers who can give quick service, some of the old, well-established manufacturers have set up branch factories at strategic points. This trend toward decentralization in marketing, with the advantage it has given to local manufacturers, has obviously militated greatly against the development of concentrated ownership and control in the industry.

(3) Retail stores have forced sales by allowing liberal credit arrangements and have found themselves with assets frozen in uncollectible installment accounts during economic downturns. Since there is no satisfactory market for used furniture and the cost of storage, handling, etc., in many cases would increase the dealer's loss if he were to repossess, he has purchased with extreme caution in recent years, seeking by every device to gain the best possible terms of sale. By playing one producer against another, retailers greatly intensify competition among manufacturers. Manufacturers, finding that their outlets are curtailed, that retailers only gradually work off their accumulated stocks, and that they will have no volume whatsoever unless they meet the buyers' rigid terms, are forced not only to grant liberal credit concessions, but are compelled to reduce prices to the lowest possible levels. This obviously contributes greatly to vigorous price competition in the industry.

(4) Finally, the furniture industry has been characterized by a conspicuous inadequacy of accounting methods up to very recent years. Manufacturers who are not sure of their costs may be tempted by a large order to quote prices which, if not actually below the cost of production, offer only a minimum margin of profit. Even producers who are fairly confident of their accounting methods are often inclined to reduce their prices below a profitable level on particular orders, because of their desire to meet the prices of any competitor; yet prices of competitors are often based upon inadequate cost accounting methods. All these factors have contributed toward making

the furniture industry one of the mostly highly competitive in the American economy.[10]

Productivity and Price.

As in the cotton goods and woolen and worsted goods industries, the most striking characteristic of the unit labor requirement-price relationship in the furniture industry is the similarity of movement of the two indexes.

The decline in unit labor requirements from 1920 to 1922 was accompanied by a more precipitous drop in price while both indexes leveled off during 1922–23. Both series fell approximately the same extent from 1923 to 1926, and they continued to parallel each other to 1928. In 1929 the unit labor requirement index dropped slightly below the price series, but in 1930 it rose again to approximately the same level as that of the price series. Beginning in 1931, however, the indexes parted company. The curtailment of output brought about by the depression resulted, on one hand, in a marked decline in prices and, on the other, in an increase in unit labor requirements. This divergence was greatest in 1933 with the unit labor requirement index at 99.5 and the price series at 75.1. In 1934 the price index increased slightly while labor required per unit decreased more sharply but in 1935 they both began gradual upturns.

The practical uniformity of the two series from 1920 to 1930, and especially from 1923 to 1928, is one of the most striking unit labor requirement-price relationships in this study. The trend of the indexes in recent years seems to indicate that this parallelism to a considerable extent has been reestablished.

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[10] For a more detailed treatment of some aspects of these competitive problems, see U. S. Bureau of Foreign and Domestic Commerce, Furniture Distribution in the Midwest, by C. R. Niklason, Domestic Commerce Series No. 75, 1932.

APPENDIX I

EMPLOYMENT IN INDUSTRIES CLASSIFIED ACCORDING TO THE AMOUNT OF ELECTRICAL ENERGY USED PER MAN-HOUR IN PLANTS OF VARYING SIZE, 1937[1]

Industries in which electric energy used per man-hour is highest in plants employing—[2]

I. 1 to 50 wage-earner group:	*Employment*
Liquors, malt	39,856
Cotton narrow fabrics	11,002
Knitted outerwear:	
Contract factories	2,241
Regular factories	19,630
Work garments (including work shirts) and sport garments, except leather	47,325
Furnishing goods, men's, not elsewhere classified—regular factories	7,031
Men's, youths', and boys' clothing, not elsewhere classified:	
Contract factories	22,145
Regular factories	76,691
Perfumes, cosmetics, other toilet preparations	9,242
Blackings, stains, and dressings	1,336
Radios, radio tubes, and phonographs	46,337
Machine repair shops	3,787
Dyeing and finishing of cotton yarns	5,358
Recovered wool fiber	2,772
Silk broad woven goods—"commission" branch	2,179
Trousers (semidress), wash suits, and washable service apparel	9,712
Shirts (except work shirts) collars, nightwear—contract factories	6,391
Furnishing goods, men's, not elsewhere classified—contract factories	456
Men's, youths' and boys' clothing, not elsewhere classified—contract sponging, examining, etc., of material	725
Batting, padding, wadding, upholstery filling	4,168
Woolen and worsted dyeing and finishing	1,743
Leather and sheep-lined clothing	2,948
Wire drawn from purchased rods	24,052
Total for I	347,127

[1] *Employment in industries for which comparable size groupings are not available:*

Industry:	*Employment*
Dyeing and finishing of rayon (and silk) yarn	1,100
Processed cotton waste	2,054
Flour and other grain-mill products	20,660
Sugar, beet	9,024
Liquor, distilled	5,471
Wool combing—commission, and tops for sale	8,252
Rayon yarn and thread—processed for sale	4,847
Silk broad woven goods—"regular" branch	12,752
Knitted gloves and mittens	3,182
Men's underwear—regular factories	6,410
Sheet metal work, not specifically classified	17,864
Wirework, not elsewhere classified	25,846
Motor-vehicle trailers	5,179
Total	117,641

[2] In arriving at the figure representing the highest use per man-hour of electric energy, selections were made for the 1 to 50 wage-earner group from its three component groups: 1 to 5, 6 to 20, and 21 to 50; and selections were made for the 501 and over wage-earner group from the component groups: 501 to 2,500, 2,501 and over, and, where given, the 501 and over group.

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	Employment
II. 51 to 100 wage-earner group:	
Tobacco (chewing and smoking) and snuff	9, 746
Rayon throwing and spinning—commission only	1, 770
Rayon broad woven goods—"commission" branch	2, 610
Rayon narrow fabrics	5, 001
Silk throwing and spinning—commission only	12, 072
Silk yarn and thread—made for sale	9, 452
Pulp (wood and other fiber)	25, 680
Insecticides and fungicides	2, 821
Nonclay refractories	5, 230
Steel barrels, kegs, and drums	6, 140
Total for II	80, 522
II. 101 to 500 wage-earner group:	
Feeds, prepared, for animals and fowls	11, 759
Dyeing and finishing of cotton fabric	46, 904
Woolen yarn	2, 397
Felt goods, except woven felts	3, 349
Paper-fiber and grass carpets and rugs	788
Silk narrow fabrics	4, 259
Men's underwear—contract factories	1, 424
Paper	104, 112
Soap	13, 764
Cleaning and polishing preparations	2, 852
Leather, tanned, etc.:	
Contract factories	2, 190
Regular factories	45, 603
Rubber goods other than tires, inner tubes, and boots and shoes	44, 137
Cement	24, 808
Lime	8, 797
Copper smelting and refining	14, 514
Lead smelting and refining	4, 036
Zinc smelting and refining	11, 265
Smelting and refining, nonferrous metals other than gold, silver, platinum, not from the ore	4, 526
Wrought pipe, welded and heavy-riveted	13, 635
Total for III	365, 119
IV. 501 and over wage-earner group:	
Cereal preparations	7, 887
Meat packing, wholesale	119, 283
Sugar refining, cane	14, 024
Cigars	50, 442
Cigarettes	26, 149
Cotton yarn and thread	76, 706
Cotton woven goods (over 12 in. in width)	318, 283
Worsted yarn	15, 478
Woolen woven goods, including woven felts	58, 109
Worsted woven goods	68, 443
Woolen and worsted carpet yarn	2, 385
Wool carpets and rugs (other than rag)	30, 496
Rayon broad woven goods (18 inches wide and over), "Regular" branch	50, 497
Dyeing and finishing of rayon and silk fabric	15, 669
Hosiery	125, 958
Knitted cloth	9, 907
Knitted underwear	36, 028
Shirts (except work shirts), collars, nightwear; regular factories	40, 905
Rayon and allied products	55, 098
Drugs and medicines	21, 336
Petroleum refining	79, 622
Rubber boots and shoes	18, 356
Rubber tires and inner tubes	63, 290
Clay products, other than pottery	46, 769

	Employment
IV. 501 and over wage-earner group—Continued.	
Pottery, including porcelain ware	28, 264
Glass	73, 997
Aluminum products	23, 337
Nonferrous-metal alloys; nonferrous-metal products, except aluminum, not elsewhere classified	77, 694
Blast-furnace products	22, 580
Steel-works and rolling-mill products	473, 215
Cast-iron pipe and fittings	15, 909
Plumbers' supplies, not including pipe or vitreous-china sanitary ware	23, 417
Tin cans, other tinware, not elsewhere classified	32, 248
Stamped and pressed metal products; enameling, japanning, and lacquering	54, 840
Electrical machinery, apparatus and supplies	243, 513
Machine tools	45, 875
Machine-tool accessories and machinists' precision tools	28, 977
Machinery not elsewhere classified	126, 663
Machine-shop products	89, 519
Engineers, turbines, water wheels, and windmills	28, 723
Refrigerators, refrigerating, ice-making apparatus	47, 643
Motor-vehicle bodies	84, 597
Motor-vehicle parts and accessories	189, 071
Motor vehicles, not including motorcycles	190, 323
Total for IV	3, 251, 525

Source: U. S. Bureau of the Census, Census of Manufactures: 1937, Man-Hour Statistics for 105 Selected Industries, table 1, pp. 3–5.

APPENDIX J

METHODOLOGY OF CORRELATING POWER DIFFERENTIAL AND ECONOMIC CONCENTRATION

(1) The electric energy used per man-hour was averaged for the three smallest groups of plants for which data are available, i. e., those employing 1 to 5, 6 to 20, and 21 to 50 wage-earners. No weighting factors were utilized in computing the average, for the reason that, in most industries, the number of wage-earners employed in these small plants constitutes such a slight proportion of the industry's total, the process of weighting by the number of wage-earners would not change materially the calculations. Furthermore, the purpose of the analysis—to compute the power differential between large and small plants—does not rest in any way upon the proportion of the industry's wage-earners employed in the various groups of plants; the question of employment in plants of varying sizes relative to their use of power has already been discussed.

(2) The electric energy used per man-hour for the large plants was taken for the one group of plants employing over 100 workers which was characterized by the largest use of electric energy per man-hour. Selections from 5 size classifications (not invariably contiguous in the primary data) could thus be made.[1] These size groupings together with the number of industries represented by each in the correlation are as follows:[2]

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[1] This is due to the possibility of disclosure of individual firms.

[2] Industries in each optimum large size group:

1. 101 to 500 wage-earner group:
   - Feeds, prepared, for animals and fowls.
   - Paper.
   - Insecticides and fungicides.
   - Soap.
   - Rubber goods other than tires, inner tubes, and boots and shoes.
   - Cement.
   - Lime.
   - Smelting and refining, nonferrous metals other than gold, silver, platinum, not from the ore.
   - Wrought pipe, welded and heavy-riveted.
2. 101 to 2,500 wage-earner group:
   - Flour and other grain-mill products.
   - Liquors, distilled.
   - Steel barrels, kegs, and drums.
   - Wirework not elsewhere classified.
3. 501 to 2,500 wage-earner group:
   - Cereal preparations.
   - Liquors, malt.
   - Pulp (wood and other fiber).
   - Drugs and medicines.
   - Clay products, other than pottery.
   - Pottery, including porcelain ware.
   - Cast-iron pipe and fittings.
4. 501 and over wage-earner group:
   - Cigars.
   - Glass.
   - Aluminum products.
   - Machine tools.
   - Machine-tool accessories and machinists' precision tools.
   - Engines, turbines, water wheels, and windmills.
5. 2,501 and over wage-earner group:
   - Petroleum refining.
   - Electrical machinery, apparatus, and supplies.
   - Radios, radio tubes, and phonographs.
   - Bodies (motor-vehicle).

Number of industries represented

Size of plant (by number of wage-earners):	
101 to 500	9
101 to 2,500	4
501 to 2,500	7
501 and over	6
2,501 and over	4
Total	30

(3) The percent difference between the two figures arrived at in (1) and (2) was then computed, with the figure representing the small plants serving as the base.[3]

[3] It is widely believed that any differentiation between large and small plants must be made on the basis of each specific industry involved, since a plant which appears large in one industry would seem small in another. To a certain extent this is true, but many industries, which by the very nature of their productive processes might be considered unfavorable to the operation of large units, are found to have plants in the two largest size groups. Of the 30 industries in the correlation only 4—feeds, prepared; insecticides and fungicides; lime; and smelting and refining of nonferrous nonprecious metals not from ore—report the largest size groups employed as under 501 (see following table). This indicates that large-scale operation has been extended throughout the framework of American manufacturing enterprise and is not confined to a few basic industries.

Largest size group reported for industries in the correlation

Industry:	*Largest size group reported*
Flour and other grain-mill products	101–2,500.
Feeds, prepared, for animals and fowls	101–500.
Cereal preparations	501–2,500.
Distilled liquors	101–2,500.
Malt liquors	501–2,500.
Cigars	501 and over.
Paper	501–2,500.
Pulp (wood and other fiber)	501–2,500.
Drugs and medicines	501–2,500.
Insecticides and fungicides	101–500.
Soap	501–2,500.
Petroleum refining	2,501 and over.
Rubber goods, other than tires, inner tubes, and boots and shoes	501–2,500.
Cement	501–2,500.
Lime	101–500.
Clay products, other than pottery	501–2,500.
Pottery, including porcelain ware	501–2,500.
Glass	501 and over.
Aluminum products	501 and over.
Smelting and refining, nonferrous metals other than gold, silver, and platinum, not from ore	101–500.
Cast-iron pipe and fittings	501–2,500.
Wrought pipe, welded and heavy riveted	501–2,500.
Steel barrels, kegs, and drums	101–2,500.
Wirework, not elsewhere classified	101–2,500.
Electrical machinery, apparatus, and supplies	2,501 and over.
Radios, radio tubes, and phonographs	2,501 and over.
Machine tools	501 and over.
Machine tool accessories and machinists' precision tools	501 and over.
Engines, turbines, water wheels, and windmills	501 and over.
Motor vehicle bodies	2,501 and over.

This does not mean that the very largest plants are necessarily the most efficient. Since the purpose of the comparison was to contrast the degree of efficiency of large-size groups with that of small groups, a selection was made among all groups employing 100 or more workers to determine the degree of efficiency of the optimum large-scale plant.

As a matter of fact the four industries in which the largest size group reported was that of 101–500 could be eliminated from the correlation without affecting materially the result. But it was believed that plants employing 101–500 workers could not be regarded as small units of production, especially in cases where they were the largest units reported. A precedent existed for this belief. Prof. P. Sargant Florence's classification of size of plants, based upon somewhat different size groupings (the old census size groupings), was as follows: Minute (1 to 5 wage earners), very small (6 to 20), small (21 to 50), smallish (51 to 100), medium (101 to 250), largish (251 to 500), large (501 to 1,000, and very large (1,001 and over). (P. Sargant Florence, The Logic of Industrial Organization, Kegan, Paul, Trench, Trubner & Co., Ltd., London. 1933, p. 29.) According to this classification, plants employing 101 to 500 workers w[illegible] represent a combination of medium (101 to 250) and largish (251 to 500). Since it was desired to include as many industries as possible in the correlation, and since a distinct difference existed between plants of that size and the groups selected to represent the small plants they were included with other obviously large plants in the determination of the degree of optimum efficiency of large-scale operation.

(4) For the concentration data, recourse was made to the statistics denoting the percent of the industry's value of products produced by the industry's four largest concerns, as computed for 1935 by the National Resources Committee.[4]

It will thus be noted that while the figures for the power differential are for 1937, the concentration data are for the previous biennial census year of 1935. This use of different years may be explained, first, by the fact that figures showing the electric energy used per man-hour in 1935 were available only for 59 industries, whereas in 1937 they could be obtained for 105 industries, and second, by the realization that relatively little change in the degree of an industry's concentration, except in the case of very rapidly expanding industries, could be expected to occur in the short space of those 2 years.

(5) It will be observed that 30 industries are represented in the correlation, whereas the primary data on electric energy per man-hour was, in some form or another, available for 105 industries. It was found, however, that in the case of 8 industries, data for all, or any differentiated part, of the 1 to 50 wage-earner group were not available; in these cases the smallest size classification exceeded that of 50 wage-earners per plant. For 55 additional industries (of which 45 were in the industry group, "Textile Mills and Apparel") no concentration data were available. The concentration data compiled by the National Resources Committee for textiles related to broad industry groups, such as "Cotton Manufactures" whereas the electric power data were available only for the particular industries, such as "Cotton Woven Goods," which constituted but segments of the broad groups.

For 13 additional industries the use of electric energy per man-hour was considered inadequate as a measure of the technological advantage which large plants may possess over small ones. There are three basic causes, in the case of most of these industries, for this inadequacy. In the first place, some of the industries, such as meat-packing, by the very nature of their productive processes make relatively little use of those types of equipment which could be powered by electrical energy. In a second group of industries, such as the manufacture of tin cans, the process of production in a small plant would involve almost identically the same type of equipment that would be used in a large plant. And thirdly, in some of the industries, such as machine shop products, the industry, as defined by the census, covers such a multitude of products and processes that a comparison between large and small plants might involve processes of a very different nature.

Thus 8 industries were eliminated because of the fact that figures of electric energy used per man-hour in the 1 to 50 wage-earner size group were not available; 54, because concentration data were not available; and 13, because the use of electric energy per man-hour is unsuited as a measure of the technological advantage which large

[4] National Resources Committee, The Structure of the American Economy, Part I, 1939, appendix 7, table 1, pp. 240–249.

plants may possess over small plants, making a total of 75 industries which could not be included in the correlation.[5]

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[5] Industries not included in the correlation:

(I) Industries for which concentration data are not available:
- Cleaning and polishing preparations.
- Bleachings, stains, and dressings.
- Leather, tanned, etc.:
  - Contract factories.
  - Regular factories.
- Nonclay refractories.
- Sheet-metal work, not specifically classified.
- Machine repair shops.
- Motor vehicle parts and accessories.
- Motor vehicle trailers.
- Textile mills and apparel group (45).

Total, 54.

(II) Industries for which electric energy used per man-hour in the 1–50 wage-earner plant size group are not available:
- Sugar, beet.
- Sugar refining, cane.
- Rayon and allied products.
- Rubber boots and shoes.
- Rubber tires and inner tubes.
- Copper smelting and refining.
- Lead smelting and refining.
- Zinc smelting and refining.

Total, 8.

(III) Industries for which the use of electric energy per man-hour constitutes an inadequate measure of the technological advantage which large plants may possess over small plants:
- Meat packing.
- Cigarettes.
- Tobacco and snuff.
- Perfumes, cosmetics, and other toilet preparations.
- Nonferrous metal alloys and products, not elsewhere classified.
- Blast furnace products.
- Steel works and rolling mills.
- Tin cans and other tinware.
- Stamped and pressed metal products.
- Wire drawn from purchased rods.
- Machine shop products.
- Refrigerators, refrigerating and ice-making apparatus.
- Motor vehicles, not including motorcycles.

Total, 13.

The 30 remaining industries, however, are widely scattered among each of the basic fields of manufacture other than textiles and apparel: Food and tobacco industries; chemical industries (i. e. making or using chemicals, or employing chemical processes); stone, clay, and glass industries; nonferrous metal industries; and iron and steel and their products, including machinery. Employment in these industries during 1937 amounted to 1,177,617 wage-earners, or 39.7 percent of the total number of wage-earners in all fields, excepting textiles and apparel, included in the primary data.

APPENDIX K

TECHNICAL PROGRESS AND ECONOMIC WELFARE

AN OUTLINE OF TOPICS FOR STUDY

[This Outline of Topics for study of technology was prepared by Dr. Lewis Lorwin. Had time permitted, it would have been followed in writing part 1 of the monograph. It is offered here for the use of students of technological developments]

I. The Meaning of Technical Progress

1. Is there agreement in use of term?
2. Various meanings in which used.
3. Wide scope of term.
4. What use shall be accepted?
5. Problem of relation of technical change to economic welfare.

II. Nature, Forms, and Rate of Technical Progress

1. Motives and causes of technical progress:
   - (*a*) Science and technology; the inventive impulse; to what extent have technical improvements been stimulated by the growth of science (and vice versa, effects of empirical technical progress on science), or by industrial experience.
   - (*b*) The needs of industry and the profit motive.
   - (*c*) Organized and systematic industrial research.
   - (*d*) The effects of the patent system.
   - (*e*) The influence of the social environment (a society dedicated to rapid economic and social change).
   - (*f*) Special methods for stimulating technical changes (expositions, rewards, etc.).
   - (*g*) Resistances to technical change.
2. Forms and types of technical chemical progress:
   - (*a*) Elements of technology, nature of inventions and technical improvements; basis of classification.
   - (*b*) Types of technical progress.
     - (1) Physical and biological:
       - Materials and processes: Discovery of new materials, improved use of old by means of new processes: growing importance of application of chemicals and chemical processes; synthetic materials; utilization of waste products; improvement of seeds, breeds, etc.
       - Power and fuel: New sources of power; better utilization of coal, gas, oil, and water power; improved capacity for working coal deposits, etc. Allocation of various types of power to different industries.

2. Forms and types of technical progress:
    (2) Mechanical: Machinery, implements, tools, etc. Basic machines and machine processes; description of machinery used in different industries; mechanical changes in different industries; growth and degree of mechanization of specific industries.
    (3) Managerial: Rationalization (its motives and methods); scientific management (concept and procedures); improved management dependent on specialized and improved equipment (interaction of managerial and mechanical changes); industrial standardization, utilization of waste products; time and motion studies, personnel and employment policies (reduction of labor turn over and absenteeism; adjustment to and training for job); incentives to greater efficiency (loyalty to firm, etc.); improved cost accounting.
    (4) Structural: Change in nature of product; new methods of production, integration of plants, development of new products and industrial areas.
  (*c*) Functional classification—innovations and improvements (Lederer); labor-saving and capital-saving devices, etc.
3. Rate of technical progress:
  (*a*) Factors of fluctuation in growth of technical improvements; rapidity of utilization (depending on character of technical devices, business conditions, structure of industry, policies of business concerns, etc.); resistance to innovations.
  (*b*) Measurement of rate of technical progress; methods of measurement.
  (*c*) Comparison of different periods in this respect in the United States (1899–1914; 1919–29; 1930–39); technical advance in specific industries at different periods.
  (*d*) What determines rate of technical progress?
  (*e*) Is there an "optimum" rate of technical change? Can it be secured through the processes of competition?

III. Technical Changes in American Industry

1. Technical advance in specific industries.
2. Periods of greatest technical advance in different industries.
3. Conditions in different industries affecting adoption of technical improvements (inventions, patents, rapidity of adoption of new devices, policies of business concerns, banking system, etc.)

IV. Technical Change and Agriculture

1. Mechanization of agriculture as a factor in farm-city population movements.
2. Effects of technical change on status of agriculture in national economy.

3. Farm ownership and tenancy—as affecting use of machinery and the application of technical improvements. Land tenure as influenced by size of holdings and type of farm. Technical changes in methods of farming as affecting costs of production.
4. Technical progress and agricultural depressions.

V. Technical Change and Some Aspects of the Economic Process

1. Primary effects:
   (*a*) Time-saving and increase in productivity.
   (*b*) Changes in plant organization and methods of production.
   (*c*) Changes in supply of and demand for labor.
2. Secondary:
   (*a*) Changes in cost-price relationships.
   (*b*) Changes in distribution of purchasing power and in consumption patterns.
   (*c*) Changes in supply of and demand for capital.
   (*d*) Changes in volume and composition of national income.
3. Round about:
   (*a*) Changes in monetary policy.
   (*b*) Effects of technical change on cyclical movements.

VI. Technology and Economic Concentration

1. Technical change as a factor in the growth of large scale industry and business. To what extent does it operate through increasing efficiency of large business, through control of patents, control of investment funds, etc. Illustrations for separate industries.
2. Effects of economic concentration on technical advance (through monopolistic control of patents, of funds for research and development, etc.).
3. Industrial techniques and monopolistic trade practices in individual industries. A description and analysis of methods used in different industries for the control of supply, for market controls, price fixing, etc.
4. Concentration in the distributive trades as a result of technical improvements. Its effects on price making and price policy, and indirectly on consumer expenditures.
5. To what extent is technical progress a factor in the elimination of small scale enterprise. Under what technical conditions can small scale industry survive? Modern technique and industrial home work.
6. The technical basis for the deconcentration and decentralization of industry.

VII. Effects of Technical Progress on Labor

1. Changes in type and location of labor demanded:
   (*a*) Technical progress and structural changes in industry.
   (*b*) Technical change and migration of industry. (Industrialization of the South.)
   (*c*) Effects of mechanization on skill requirements in different industries.
   (*d*) Technical improvements and occupational shifts.

2. Productivity, wages and the national income:
   - (*a*) Effects of machinery and labor-saving devices on wage-rates and earnings; effects of changes in skill due to technical changes.
   - (*b*) Effects on methods of wage payment and wage incentives.
   - (*c*) Effects of specialized processes on classification of workers and wages.
   - (*d*) Increasing productivity and wages in American industry, 1922–39.
3. Unemployment and occupational shifts:
   - (*a*) Estimates of industrial unemployment in the United States; part-time employment.
   - (*b*) Incidence and duration of unemployment.
   - (*c*) Occupational statistics show "that changes in techniques and markets have produced displacement on a large scale." (Changes produce idleness not by increasing lay-off, but by decreasing the hiring rate.)
   - (*d*) Technological change as aggravating factor in seasonal and cyclical unemployment.
   - (*e*) Significance of non-mechanical factors in labor productivity and displacement.
   - (*f*) Explanations of short-run effects of the introduction of technical improvements on number, kinds, and location of jobs.
     - (1) Technical improvements cause increase in productivity; marginal productivity of labor and capital change relatively to each other; labor's marginal productivity is reduced; but institutional frictions prevent corresponding fall in wages; hence wages are too high; hence unemployment.
     - (2) * * * "technological changes may be so rapid and so far-reaching that they bring about a condition in which all factors of production may be simultaneously unemployed."
4. Possibilities of reabsorption:
   - (*a*) How to measure the labor absorbing power of American industry;
   - (*b*) Occupational readjustments of displaced workers;
   - (*c*) Employment possibilities in new industries;
   - (*d*) Selective factors in an expanding labor market.
5. Personal and social aspects of workers' life:
   - (*a*) Fatigue, monotony of work; boredom, accidents, and safety.
   - (*b*) Occupational diseases and obsolescence; occupational age limits; life-time productivity.
   - (*c*) Absenteeism; labor turn-over;
   - (*d*) Standards of living in declining industries;
   - (*e*) Worker's emotional life.

VIII. Benefits and Cost of Technical Progress

1. What are benefits of technical progress; how measured:
   - (*a*) Increase in productivity;
   - (*b*) Capital accumulation;

(*c*) Possibilities of economic expansion;
(*d*) Basis for higher standard of living.

2. The costs of technical progress (economic and social; change may occur at an "uneconomically rapid rate"):
   (*a*) Obsolescence of property and capital.
   (*b*) Obsolescence of occupations; industrial dislocations.
   (*c*) Destruction of workers' skill and occupational shifts.
   (*d*) Expenses of retraining and occupational readjustment.
   (*e*) Loss of income by displaced workers.
   (*f*) Diminution in workers' income (relative to total income); hence greater inequality in the distribution of wealth and income.
   (*g*) Shift in economic structure and need for social readjustments.
3. Distribution of gains and costs:
   (*a*) Who gets largest part of benefits? Initiators of change or community at large?
   (*b*) Who pays cost of change?
   "Both the benefits and the costs fall in large degree upon the community at large * * *."
   (*c*) Can costs and benefits be balanced? How?
   "Unfortunately, competition affords no method by which the benefits of innovations can be balanced against the costs" * * *
   (*d*) Subsidy—results in fact that "the cost of change tends to be excessive and that many changes occur at an uneconomically rapid rate" (present system gives "enormous subsidy" to change).
   (*e*) How can costs be kept at a minimum?

IX. Control of Technical Progress

1. Reasons for restrictive attitudes toward technological change:
   (*a*) Business—to protect existing plants and investments; fear of loss through obsolescence; reluctance to increase debt; desire for monopoly profits, etc.
   (*b*) Labor—makes for unemployment; causes destruction of skills, etc.
   (*c*) Social (consumers)—does not decrease total costs of production. Must take into account costs of capital destruction and of supporting idle men.
   (*d*) Change subsidized under present system to a dangerous degree.
2. Reasons for control:
   (*a*) More order and security in economic life.
   (*b*) Better guidance of direction of social change.
3. Possibility and extent of control:
   (*a*) Inventions are seldom "sudden"; most of them are slow in development and not too radical in character; hence control is possible.
   (*b*) Unguided adjustments to technical changes no longer easy for individual or beneficial to society.
   (*c*) To what extent is control exercised today—and how?
4. Methods of control.

X. Protection of Worker Against Effects of Rapid Technical Change

(*a*) Advocated by J. S. Mill and others.
(*b*) Elasticity of demand as a basis for predicting labor displacements.
(*c*) Limitation of profits. ("If the profits of innovations possessing legal monopoly rights were reduced, prices conforming more nearly to lowered cost, consumers' purchasing power would be enlarged and the chain of forces which build for employment would be set in motion.")
(*d*) Dismissal wage (would cost be borne by employer or State: Would burden be shifted to consumer?) as a means of retarding introduction of labor-saving devices. ("Social responsibility for victims of technological change.")

"Conversely, it will be argued that since technological progress results in an advance in real wages even when prices are rising, and a greatly augmented increase in real wages when the general price level is falling, the worker should bear some of the cost incident to technological change."
(*e*) Placement and vocational guidance.
(*f*) Regularization of employment.
(*g*) Shorter work-week.
(*h*) Unemployment insurance.
(*i*) Unemployment Relief and Public Works.
(*j*) Wage subsidies.
(*k*) Government spending.
(*l*) Decentralization of industry.

XI. Some Major Issues Today

1. Is "capitalism" unable to absorb further technical improvements?
2. Effects of technical change in shifting the balance in world basic industries (coal, cotton, etc.) and in world economic power.
3. Technical change and democracy. Do technical developments provide a basis for a new agro-industrialism based on social control of the strategic economic forces (electric power, transportation, banking), decentralization of secondary industries, and wide diffusion of gains from technical advance—which would supply an economic foundation for a Renaissance of political and social democracy?

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